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THE MULTIPATHWAY HUMAN HEALTH RISK ASSESSMENT BASED ON THE SQI EMISSION RATES MEASURED DURING THE TRIAL BURN OF BASIN F LIQUID INDICATES THAT THE MAXIMUM LEVEL OF HUMAN HEALTH RISK ASSOCIATED WITH OPERATION OF THIS INCINERATOR WILL NOT EXCEED THE BENCHMARK RISK LEVELS DEFINED IN THE FINAL DECISION DOCUMENT (WOODWARD-CLYDE, 1990).

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INTERIM RESPONSE ACTION

BASIN F LIQUID INCINERATION PROJECT

DRAFT FINAL HUMAN HEALTH RISK ASSESSMENT

VOLUME I

SEPTEMBER 1993

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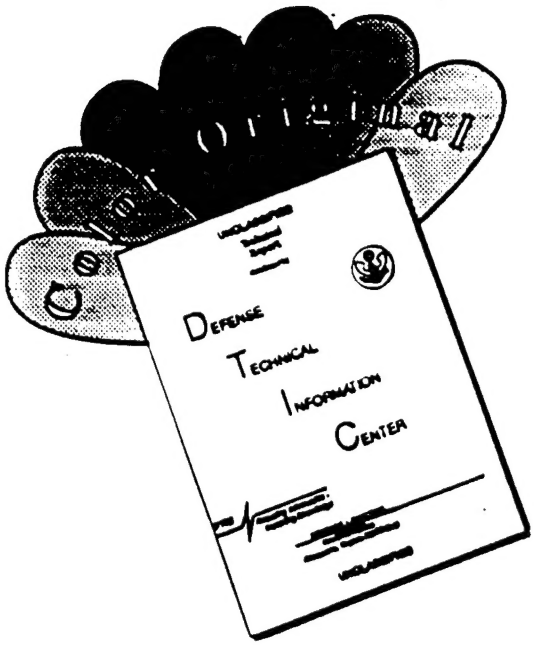

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INTERIM RESPONSE ACTION
BASIN F LIQUID INCINERATION PROJECT

DRAFT FINAL HUMAN HEALTH RISK ASSESSMENT

VOLUME I

September 1993

Prepared by:

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EXECUTIVE SUMMARY

SITE BACKGROUND

The Rocky Mountain Arsenal (RMA) is a U.S. Army facility located just north of Stapleton International Airport in Denver, Colorado. One of the reasons for environmental concern at the RMA is the presence of a large volume of liquid waste from prior chemical munitions and pesticide manufacturing activities. This liquid waste was originally located in an evaporation pond termed Basin F, and has since been moved to steel holding tanks and a lined pond. Submerged quench incineration has been selected as the most appropriate means for destroying this liquid waste (Woodward-Clyde, 1990). Construction of the Submerged Quench Incinerator (SQI) was completed by Roy F. Weston, Inc., (WESTON®) in the spring of 1993.

PREVIOUS REPORTS RELATING TO HUMAN HEALTH RISK ASSESSMENT

In order to design the SQI, it was necessary to define the upper limit of human health risk that could be associated with operation of the incinerator. This definition of "benchmark" risk levels was provided in the *Final Decision Document* (Woodward-Clyde, 1990) as follows:

> "To be consistent with EPA guidance that Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) remedial actions be protective of human health and the environment, operation of the SQI facility should create no cumulative excess cancer risk higher than 1E-06 (1 in 1 million) for carcinogens, or hazard index greater than 1 for noncarcinogenic compounds, in the nearest exposed population, whether on or off the arsenal."

In order to determine whether the design and actual operation of the SQI would meet or exceed the benchmark human health requirements, WESTON prepared several reports prior to this final risk assessment which dealt with the human health risks that might potentially be associated with the operation of the incinerator, including the following:

- *Final Draft Risk Assessment*, July 1991, 4 volumes (WESTON, 1991). This was a predictive risk assessment, based on the design specification for the SQI, the planned operating conditions, and the chemicals expected to be present in stack emissions. The predicted maximum cancer risk was well below the benchmark levels.

- *Evaluation of Detection Limits for the SQI Trial Burn Data*, June 1993 (WESTON, 1993a). This report evaluated the analytical detection limits established for measuring emissions from the SQI during test runs and actual operations. The report concluded that all detection limits were low enough that a chemical could be detected at concentrations well below a level of health concern.

- *Evaluation of Miniburn Test Data for the SQI*, June 1993 (WESTON, 1993b). This report calculated the risks to the maximally exposed off-site resident based on actual operating conditions and emission rates measured during a preliminary test (miniburn) in which Basin F liquid was incinerated. The report found that the risks based on the miniburn data were less than originally predicted.

- *Finalization of Basin F Liquid Incinerator Human Health Multipathway Risk Assessment, Phase I*, July 1993 (Appendix 1A). This report investigated the potential impact of changes in regulations and risk assessment methods that have occurred since the 1991 predictive risk assessment was completed. In addition, the potential impacts of differences between the design and actual operating conditions of the incinerator were assessed. The report concluded that none of the changes in exposure or toxicity assumptions or in operating characteristics would result in a significant change in the estimated risk, and that the basic protocol used in 1991 was appropriate for evaluating the risks based on the trial burn data.

RISK ASSESSMENT METHODS AND APPROACH

All human health risk assessment calculations for the SQI were performed using the following documents as general guidance:

- *Risk Assessment Guidance for Superfund: Human Health Evaluation Manual* (EPA, 1989).

- *Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions* (EPA, 1990).

Prior to the preparation of the draft risk assessment in 1991, a detailed protocol was developed by WESTON and approved by the EPA. This protocol, which emphasized conservatism in order to avoid any possible underestimation of risk, has served as the basis for all risk assessments performed by WESTON from 1991 to 1993. The protocol is presented in Appendix 6 of this report.

SELECTION OF CHEMICALS OF POTENTIAL CONCERN

During the trial burn, samples of stack emissions were collected on three consecutive days and analyzed for over 200 different chemicals. In addition, continuous monitoring was performed for a number of acid gases and priority pollutants. Any chemical detected in one or more of the samples was considered a chemical of potential concern, and was evaluated in the risk assessment. Table ES-1 lists the chemicals detected and gives their estimated emission rate. For comparison, the emission rates predicted in 1991 are also shown. Any chemical not detected in any of the samples was not evaluated. To be thorough, however, an evaluation was also performed to estimate the maximum risk which might be contributed by chemicals present at the detection limit concentrations and from chemicals suspected to be release products but which could not be measured due to lack of appropriate methodologies.

MODELING THE FATE AND TRANSPORT OF EMISSION PRODUCTS

Products released from the SQI are dispersed by the wind to the surrounding ambient air. A mathematical model developed by the EPA, and modified by WESTON to account for wet and dry deposition, was used, with EPA Region VIII approval, to predict the concentration of pollutants in air and the total amount of pollutants deposited onto soil or surface waters.

EXPOSED POPULATIONS

Four populations were selected for risk evaluation. These populations were selected because they are likely to experience the highest levels of exposure from SQI releases. These populations are as follows:

- Resident-A — This population represents current off-site residents who live in the area predicted by the dispersion and deposition model to have the highest level of dry deposition and the highest level of ambient air concentrations. This location is directly north of the arsenal.

- Resident-B — This population represents current off-site residents who live in the area predicted by the dispersion and deposition model to have the highest level of total (wet plus dry) deposition. This location falls directly south of the arsenal.

- Farmer — This population represents people who grow crops and raise livestock in areas near the RMA. The location selected for evaluation is located just northwest of the site, at the location of maximal predicted total deposition to land currently used for agriculture.

- Worker — This population represents on-site maintenance workers, exposed to area-weighted total deposition and air concentrations.

EXPOSURE SCENARIOS EVALUATED

Each of the populations selected for evaluation may potentially be exposed to pollutants released from the SQI by a number of pathways, both direct (inhalation of chemicals in air) and indirect (ingestion or dermal contact with contaminated soil, ingestion of contaminated vegetables or animal products from impacted areas, etc). Table ES-2 summarizes the

exposure pathways which were evaluated for each population. Cancer risks were evaluated by assuming that exposure begins when the individual is an infant, since this results in the highest possible cancer risk estimate. Noncancer risks were assessed separately for each age group (infant, child, adult), since the exposure rate differs as a function of age. Workers were assumed to be exposed as adults only.

ESTIMATED EXCESS CANCER RISKS

Table ES-3 presents the estimated excess cancer risk to each of the exposed populations, calculated based on the emission rates measured during the trial burn. For comparison, the original risk predictions contained in the 1991 risk assessment are also shown.

As indicated in the table, the cancer risk to off-site residents is estimated to range from 6.5E-09 to 9.8E-09, well below the benchmark risk level (1E-06), and slightly less than the original risk estimates. The estimated cancer risk to the on-site worker (3.8E-10) is also slightly less than originally estimated. In all three of these populations, the principal source of this risk is from inhalation exposure to arsenic in ambient air. For the farmer, the estimated excess cancer risk is 3.1E-08, also well below the benchmark, but somewhat higher than originally predicted. The main source of this risk is from bis(ethylhexyl)phthalate in garden vegetables. This compound was not predicted to be present in stack emissions, and the levels detected during the trial burn may be an artifact due to laboratory contamination.

As noted above, some of the chemicals identified as potential release products in 1991 could not be detected in the stack emissions during the trial burn. If all these chemicals were present at their detection limits (this is considered to extremely unlikely), the total excess cancer risk would still be well below the benchmarks established for this facility. Also, some potential release products could not be measured due to analytical or sampling limitations. However, the cancer risk from these chemicals, based on their predicted release rates, is so low ($<$1E-13) that this is not a concern.

ESTIMATED NONCANCER RISKS

Table ES-4 summarizes the estimated noncancer Hazard Indices for each of the populations evaluated at this site, based on the emission rates measured during the trial burn. For comparison, the Hazard Indices originally predicted in the 1991 risk assessment are also shown.

As the table indicates, the highest Hazard Index value (that for the Resident-A child) is 1.9E-02. This value, and all other Hazard Index values, are well below the benchmark risk of 1E+00 established for this facility, indicating that the chemicals detected during the trial burn do not pose significant risk of any adverse noncancer health effects in any of the exposed populations. Chemicals identified as potential release products but which were not present at detectable levels in the trial burn would not contribute significant noncancer risk even if all were present at their detection limits. Based on predicted emission rates, chemicals identified as potential release products but whose release rates could not be measured are likely to contribute a hazard index no higher than 1E-01. Thus, noncancer risks do not appear to be of possible concern.

UNCERTAINTIES IN THE RISK ESTIMATES

It is important to recognize that the risk estimates presented in this document are based on a number of assumptions, and that these assumptions introduce uncertainty into the risk estimates. Assumptions are required because of data gaps in our understanding of the toxicity of chemicals, and in our ability to estimate the true level of human exposure to chemicals released to the environment. In most cases, assumptions employed in the risk assessment process are intentionally conservative (that is, they are likely to lead to an overestimate of risk). Taken together, the combined effect of these conservative assumptions makes it very unlikely that the true risk to any on-site or off-site population will exceed the calculated health risk values. It is important for risk managers and the public to take this into account when interpreting the risk estimates derived for this facility.

CONCLUSIONS

The multipathway human health risk assessment based on the SQI emission rates measured during the trial burn of Basin F liquid indicates that the maximum level of human health risk associated with operation of this incinerator will not exceed the benchmark risk levels defined in the *Final Decision Document* (Woodward-Clyde, 1990).

EXECUTIVE SUMMARY CITED REFERENCES

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TABLE ES-1
ROCKY MOUNTAIN ARSENAL (RMA)
SUBMERGED QUENCH INCINERATOR
DENVER, CO

SUMMARY OF DETECTED COMPOUNDS IN THE TRIAL BURN AND
THE 1991 PREDICTED EMISSION RATES

POLLUTANT	EMISSION RATE, g/sec		
	TRIAL BURN [a]		1991 PREDICTED [b]
Trial Burn Metals			
Aluminum(Al)		3.74E-04	6.49E-04
Antimony (Sb)		2.06E-05	2.28E-05
Arsenic (As)	ND < [c]	7.42E-05	1.29E-04
Barium(Ba)	ND <	1.48E-04	3.16E-05
Boron(B)		6.90E-04	9.63E-04
Cadmium (Cd)	ND <	3.79E-06	2.02E-05
Calcium(Ca)	ND <	3.70E-03	2.02E-05
Chromium (Cr)	ND <	7.36E-06	8.88E-06
Copper(Cu)		7.63E-03	1.21E-01
Iron(Fe)		1.69E-04	1.72E-03
Lead (Pb)		1.10E-04	4.05E-05
Manganese(Mn)		3.35E-05	2.22E-04
Mercury (Hg)		2.65E-04	3.57E-05
Molybdenum(Mo)	ND <	7.42E-05	3.97E-04
Nickel (Ni)	ND <	2.96E-05	1.03E-03
Silver(Ag)	ND <	7.36E-06	3.43E-06
Tin(Sn)		4.98E-05	2.91E-04
Titanium(Ti)	ND <	7.42E-05	2.20E-06
Vanadium(V)	ND <	3.70E-05	8.42E-05
Zinc(Zn)		1.91E-03	5.86E-04
Total 2,3,7,8-TCDD Equivalents		4.12E-12	3.55E-11
Particulate Matter		0.254	0.5000
HCl		0.039	0.1700
HF	ND <	0.0011	0.188
HNO_3	ND <	0.0011	0.140
SO_2		3.40	0.88
NO_x		1.21	1.16
CO		0.30	0.17
Cr^{+6}	ND <	1.56E-06	8.88E-06

TABLE ES-1 (cont.)
ROCKY MOUNTAIN ARSENAL (RMA)
SUBMERGED QUENCH INCINERATOR
DENVER, CO

SUMMARY OF DETECTED COMPOUNDS IN THE TRIAL BURN AND THE 1991 PREDICTED EMISSION RATES

POLLUTANT	EMISSION RATE, g/sec		
	TRIAL BURN [a]		1991 PREDICTED [b]
POHC VOST Emissions [e]			
Carbon Tetrachloride		1.13E-05	1.56E-08
Chlorobenzene	ND <	1.10E-05	4.15E-09
VOST Emissions [f]			
Chloromethane (Methyl Chloride)		1.41E-04	2.53E-05
Methylene Chloride		3.83E-04	2.62E-07
Chloroform		1.96E-04	2.70E-08
Bromodichloromethane		4.30E-05	
Dibromochloromethane		7.99E-06	
Benzene		1.24E-05	1.37E-08
Toluene		2.61E-05	2.46E-09
Styrene		1.06E-04	2.54E-05
Xylenes(total)	ND <	1.08E-05	2.73E-08
Semivolatile Organic Compounds			
Benzoic acid		5.14E-05	1.27E-05
Dimethylpthalate	ND <	9.82E-06	
Diethylphthalate		2.59E-05	
Di-n-butylphthalate		2.93E-05	
Butylbenzylpthalate		1.37E-05	
bis(2-Ethylhexyl)phthalate		1.95E-05	
Organochlorine Pesticides/PCB Emissions			
Heptachlor epoxide		2.78E-07	

[a] Value shown is the upper 95th confidence limit of the mean or the maximum value (whichever is lower).
[b] Value shown is the predicted long-term average (base case) emission rate.
[c] The symbol "ND <" implies that the chemical was detected at least once, but the average was less then the detection limit of the highest non-detected value.
[d] Pollutant not sampled for during the Trial Burn.
[e] POHC is defined as Principle Organic Hazardous Constituents.
[f] VOST is defined as Volatile Organic Sampling Train.

Table ES-2

Summary of Exposure Scenarios Evaluated

Exposure Medium	Exposure Route	Exposed Population			
		Res. A	Res. B	Worker	Farmer
Ambient air	Inhalation	X	X	X	X
Soil	Ingestion	X	X	X	X
Soil	Dermal contact	X	X	X	X
Garden veg.	Ingestion	X	X		X
Local beef	Ingestion	X	X		X
Local milk	Ingestion	X	X		X
Local fish	Ingestion	X	X		X
Mother's milk	Ingestion[a]	X	X		X

[a]Infants only

Table ES-3

Total Lifetime Carcinogenic Risk for Basin F Liquid Incineration for Four Exposure Scenarios Comparison of Trial Burn vs. Predicted Base Case (1991)[a]

Exposure Scenario	Lifetime Carcinogenic Risk	
	Trial Burn Emissions	Predicted Emissions
Resident A	9.8E-09	1.4E-08
Resident B	6.5E-09	3.6E-09
Farmer	3.1E-08	7.3E-09
Worker	3.8E-10	6.8E-10

[a]WESTON, 1991.

Table ES-4

Hazard Indices Calculated for Adult, Child, and Infants for and Basin F Liquid Incineration Under Four Exposure Scenarios Comparison of Trial Burn (1993) vs. Predicted Base Case (1991)[a]

Exposure Scenario	Hazard Index	
	Trial Burn Emissions	Predicted Emissions
Resident A		
Adult	8.5E-03	7.4E-02
Child	1.9E-02	1.7E-01
Infant	1.3E-02	1.1E-01
Resident B		
Adult	1.7E-03	1.5E-02
Child	3.9E-03	3.4E-02
Infant	2.5E-03	2.4E-02
Farmer		
Adult	3.1E-03	2.6E-02
Child	7.1E-03	6.0E-02
Infant	4.4E-03	4.1E-02
Worker		
Adult	8.7E-04	7.5E-03

[a]WESTON, 1991.

SECTION 1

INTRODUCTION

This document is the final multiple-exposure pathway, human health risk assessment for the Submerged Quench Incinerator (SQI) at the U.S. Army's Rocky Mountain Arsenal (RMA) facility. It is based on a comprehensive evaluation of the trial burn emissions tests performed during 10 to 12 June 1993.

1.1 SITE BACKGROUND

The RMA is a U.S. Army facility that occupies approximately 17,000 acres (27 square miles) in Adams County, just north of Stapleton International Airport, directly northeast of metropolitan Denver, Colorado. RMA was established in 1942 and has been the site of manufacture of chemical incendiary munitions and also the demilitarization of chemical munitions. Agricultural chemicals, including pesticides, were manufactured at RMA from 1947 to 1982. In 1956, an evaporation pond called Basin F was constructed in the northern part of RMA. Basin F had a surface area of about 93 acres and a capacity of approximately 243 million gallons. From August 1957 until its use was discontinued in December 1981, Basin F was the only evaporative disposal facility in service at RMA.

In 1986, as part of a Federal Facility Agreement, the Department of the Army (DOA), Shell Oil Company (SOC), and EPA Region VIII agreed that an accelerated remediation be undertaken pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) to contain the liquid and contaminated soils from Basin F. In a 5 June 1987 report to the court, the DOA, SOC, EPA Region VIII, and the State of Colorado agreed that 14 interim actions, including the Basin F Interim Response Action (IRA), were necessary to expedite the cleanup of RMA.

As part of the Interim Response Action, the Army selected submerged quench incineration to treat the Basin F liquid presently stored in three aboveground storage tanks (totaling 4 million gallons) and an engineered surface impoundment, Pond A (totaling approximately 6.5 million gallons). This selection process has been documented in the *Final Decision Document for the Basin F Liquid Treatment, Interim Response Action* (Woodward-Clyde, 1990). Subsequently, the Army assigned WESTON the task of designing and constructing the incineration facility.

1.2 ROLE OF HUMAN HEALTH RISK ASSESSMENT

One of the most important considerations in designing and operating the incinerator is protection of human health, both for people who might be exposed while on the site, and those who live or work in the vicinity. As described in the *Final Decision Document* (Woodward-Clyde, 1990a), the maximum risk levels considered acceptable for the reasonable maximum exposure are a 1E-06 excess cancer risk and a hazard index of 1E+00. In order to ensure that the design and operation of the incinerator would meet these requirements, several risk assessment documents have been previously prepared.

1.2.1 1991 Risk Assessment Report

A *Final Draft Human Health Risk Assessment* was submitted to the U.S. Army in July 1991 (WESTON, 1991b). This comprehensive risk assessment predicted the maximum potential risks which the SQI might pose to off-site residents and on-site workers, based on emission rates estimated from initial test burn data, waste stream analyses, and hazardous waste emissions inventories. The assessment was intended to be very conservative, and was consistent with the standard risk assessment guidelines described in the *EPA Risk Assessment Guidance for Superfund - Human Health Evaluation Manual, Part A* (RAGS) (EPA, 1989), and in *Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions* (EPA, 1990). The planned 2-year operation of the SQI resulted in a predicted maximum cancer risk of about 1E-08, and a maximum noncancer hazard index of less than

2E-01, both well below levels of potential concern (WESTON, 1991b). This 1991 risk assessment report was provided to, and reviewed by, the Colorado Department of Health and EPA Region VIII.

1.2.2 Impact of Changes Since 1991

The construction of the SQI was completed in the spring of 1993. Because actual operating and meteorological conditions (e.g., exit temperature, exit velocity, wind speed and direction) were slightly different than design specifications and weather conditions assumed in 1991, and because there have been some changes in default exposure assumptions and toxicity values, a separate evaluation was performed to investigate whether any of these changes had a significant impact on the original risk estimates. This analysis (*Finalization of Basin F Liquid Incinerator Human Health Multipathway Risk Assessment, Phase I*) (Appendix 1A) found that these changes, either individually or collectively, did not result in significant alterations in ambient air concentrations or deposition rates. Further, these changes did not result in more than a 1E-08 increase in cancer risk or a 1E-01 increase in the noncancer hazard index. Based on this, it was concluded that the risk assessment model used in 1991 was still appropriate for evaluating risks from emissions measured during the test and trial burns.

1.2.3 Assessment of Test (Miniburn) Emissions Data

Following the completion of the construction of the SQI, a series of shakedown tests ("miniburns") was conducted to evaluate the operation of the incinerator prior to the trial burn. As part of that test program, a comprehensive list of pollutants was measured during incineration of 100 percent Basin F liquid (20 May 1993). These emissions data were used to estimate the cancer and noncancer risks to the maximally-exposed off-site residential population (WESTON, 1993a) using the same air modeling approach and exposure and toxicity assumptions as were employed in the 1991 risk assessment.

The miniburn risk estimates were well below the benchmark risk levels established for the facility, and were also lower than those predicted in the 1991 risk assessment. As a double-check of the adequacy of the detection limits achieved during the miniburn, risks were also calculated assuming all nondetected chemicals were present at concentrations equivalent to their detection limits (WESTON, 1993b). Even under this worst-case assumption, both cancer and noncancer risks were still well below the benchmarks.

1.3 PURPOSE AND ORGANIZATION OF THIS DOCUMENT

This document presents the estimated risks to humans based on the chemical emission rates measured during the main trial burn of Basin F liquid on 10 to 12 June, 1993, using the same basic methods as used in the 1991 risk assessment. The organization of this document follows the basic steps of the risk assessment process. These steps, and the document sections which detail the process, are illustrated in Figure 1-1, and are summarized below.

Section 2 is a brief description of the design and function of the SQI, with a discussion of the technical components of the system.

Section 3 presents geographic and demographic characteristics of the potentially affected area around the facility. This information is needed to identify land-use patterns and assist in characterizing potentially exposed populations.

Section 4 describes the general process of pollutant identification and selection for use in the risk assessment.

Section 5 describes in greater detail how emissions data are evaluated and how the actual emission rates from the stack are estimated.

Section 6 explains the mathematical model used to evaluate the fate of the chemicals released to the atmosphere from the stack, and the predicted concentrations in ambient air,

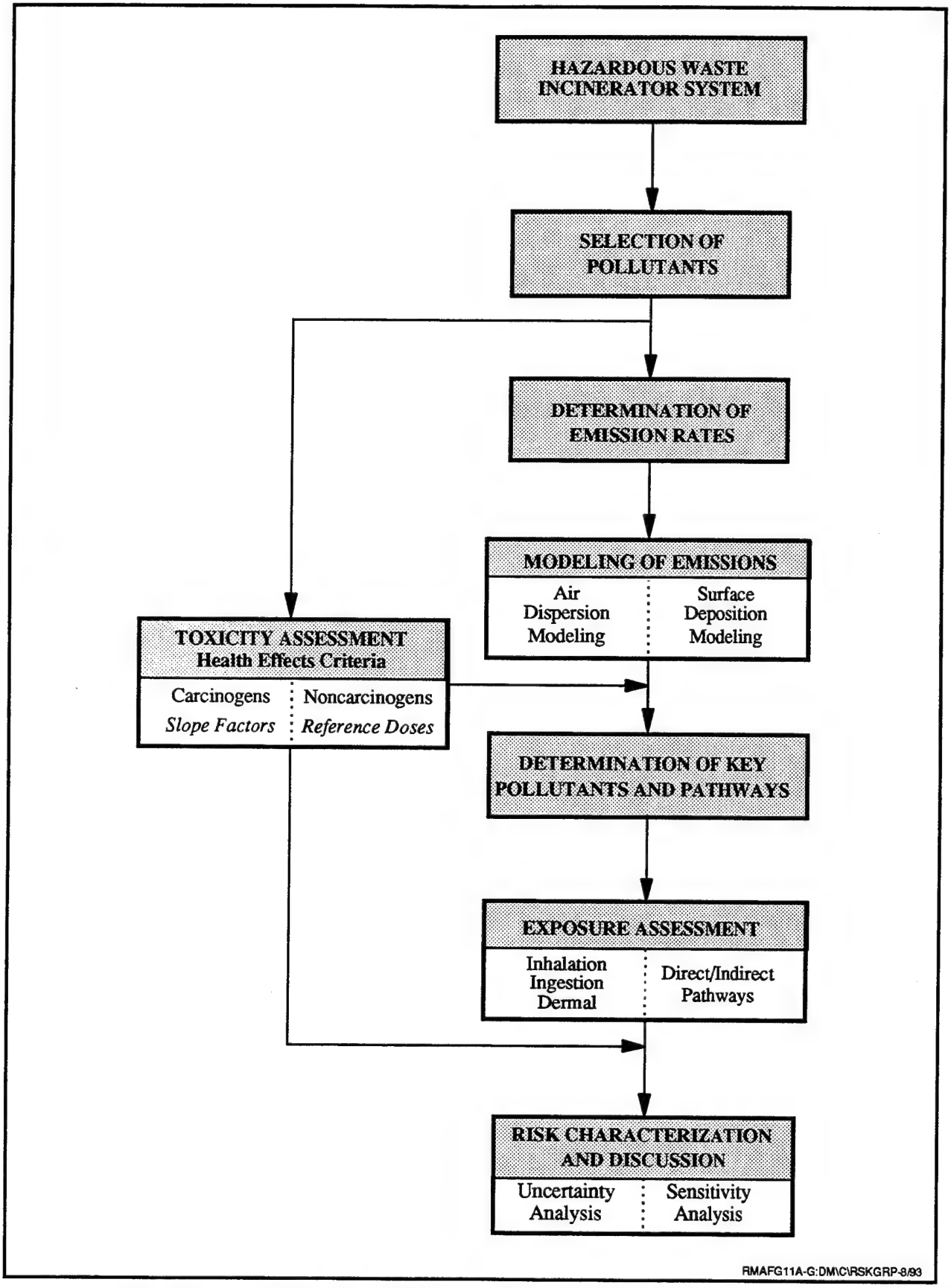

FIGURE 1-1 MULTIPATHWAY RISK ASSESSMENT PROCESS FOR HAZARDOUS WASTE INCINERATORS

soil, and surface water.

Section 7 identifies those pollutants that have a realistic potential for contributing to human exposure through direct (e.g., inhalation, soil ingestion) and indirect (e.g., consumption of contaminated vegetables, beef, dairy products, fish) pathways.

Section 8 details how potential human exposure to these pollutants from all pathways is quantified. Because there is a wide range in exposures between different people, exposure calculations focus at the high end of the distribution (the "reasonable maximum exposure").

Section 9 summarizes the toxic effects of the chemicals released from the SQI, and provides the quantitative toxicity values (slope factors, reference doses) that are needed to quantify risk levels.

Section 10 combines information on the amount of exposure with data on the health effects of the chemicals to produce a quantitative estimate of the likelihood that either cancer or noncancer effects would occur in exposed people. This section also discusses which chemicals and which exposure pathways appear to be of greatest potential concern.

Section 11 of the report discusses the uncertainties and assumptions in each step of the risk assessment process. Emphasis is placed on uncertainties that have the greatest overall impact on the total cancer and noncancer risk estimates. Understanding these uncertainties, which generally tend to lead to an overestimation of exposure and risk, is important in the proper interpretation of the risk estimates.

Tables. Because most of the tables required to present the emissions data and the risk estimates are lengthy, all tables in Volume I appear in numerical order after the reference subsection of each chapter.

Detailed calculations. Detailed documentation of all calculations is provided in Appendices 1 to 8 (Volume II of the Risk Assessment).

SECTION 1

CITED REFERENCES

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SECTION 2

FACILITY DESCRIPTION

2.1 FACILITY HISTORY

The following facility description is a summary of the information provided in the *Final Decision Document* (Woodward-Clyde, 1990) for the Basin F Liquid Incineration Project.

RMA occupies approximately 17,000 acres (27 square miles) in Adams County, directly northeast of metropolitan Denver, Colorado (see Figure 2-1). RMA was established in 1942 and has been the site of manufacture of chemical incendiary munitions and also the demilitarization of chemical munitions. Agricultural chemicals, including pesticides, were manufactured at RMA from 1947 to 1982.

In 1956, an evaporation pond called Basin F was constructed in the northern part of RMA. Basin F had a surface area of about 93 acres and a capacity of approximately 243 million gallons. From August 1957 until its use was discontinued in December 1981, Basin F was the only evaporative disposal facility in service at RMA.

In 1986, the Department of the Army (DOA), Shell Oil Company (SOC), and EPA Region VIII agreed that an accelerated remediation be undertaken pursuant to Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) to contain the liquid and contaminated soils from Basin F. In a 5 June 1987 report to the court, the DOA, SOC, EPA Region VIII, and the State of Colorado (state) agreed that 14 interim actions, including the Basin F Interim Remedial Action (IRA), were necessary to expedite the cleanup of RMA.

In the first part of the Basin F remediation, Basin F liquid was transferred to three lined steel storage tanks and to one double-lined covered pond (Pond A). Transfer of Basin F

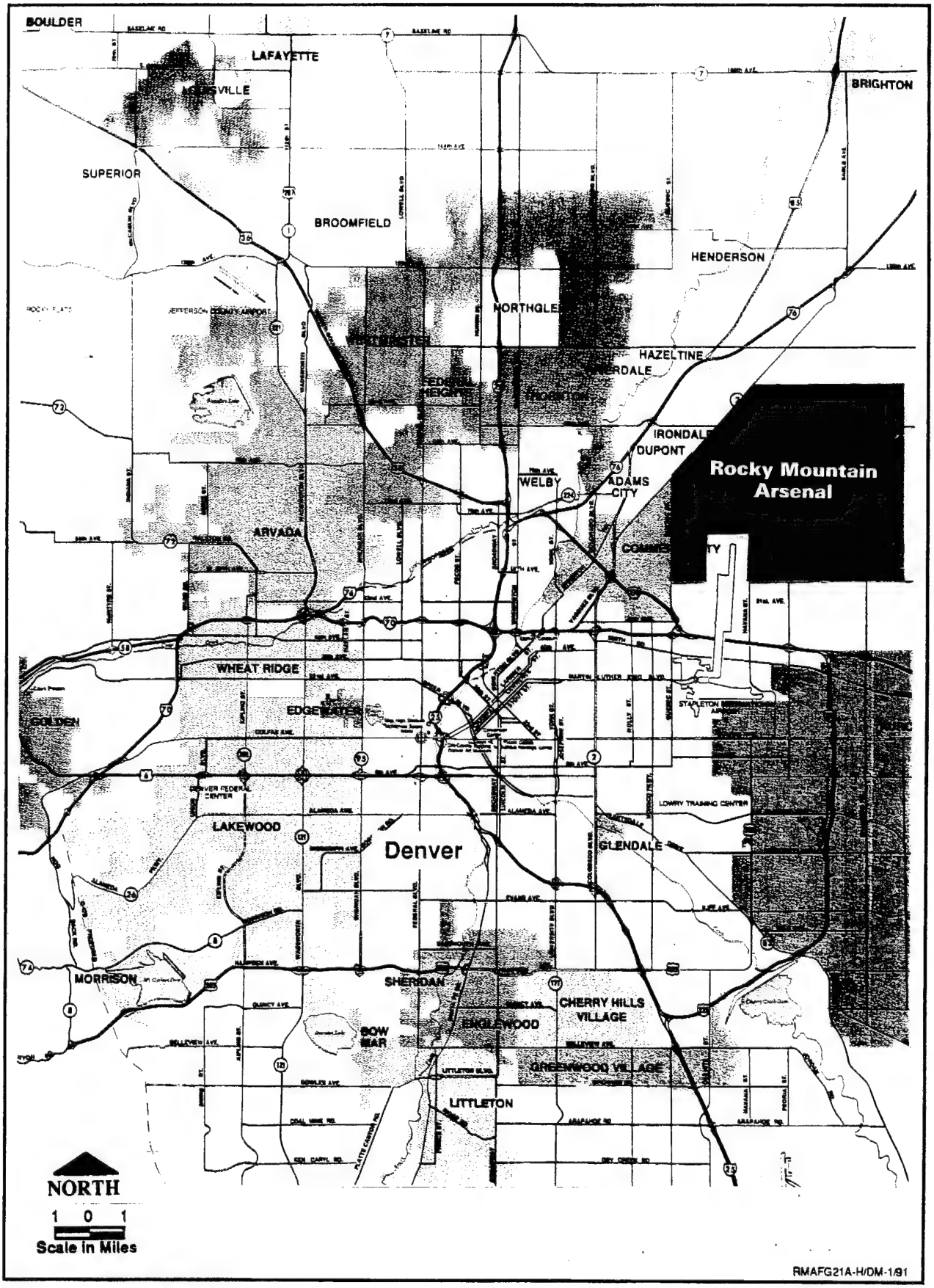


FIGURE 2-1 SITE LOCATION MAP - ROCKY MOUNTAIN ARSENAL

liquid to the tanks and Pond A for interim storage was initiated in May 1988 and completed in December 1988. Currently, approximately 4 million gallons of liquid are stored in the tank farm and 6.5 million gallons are stored in Pond A.

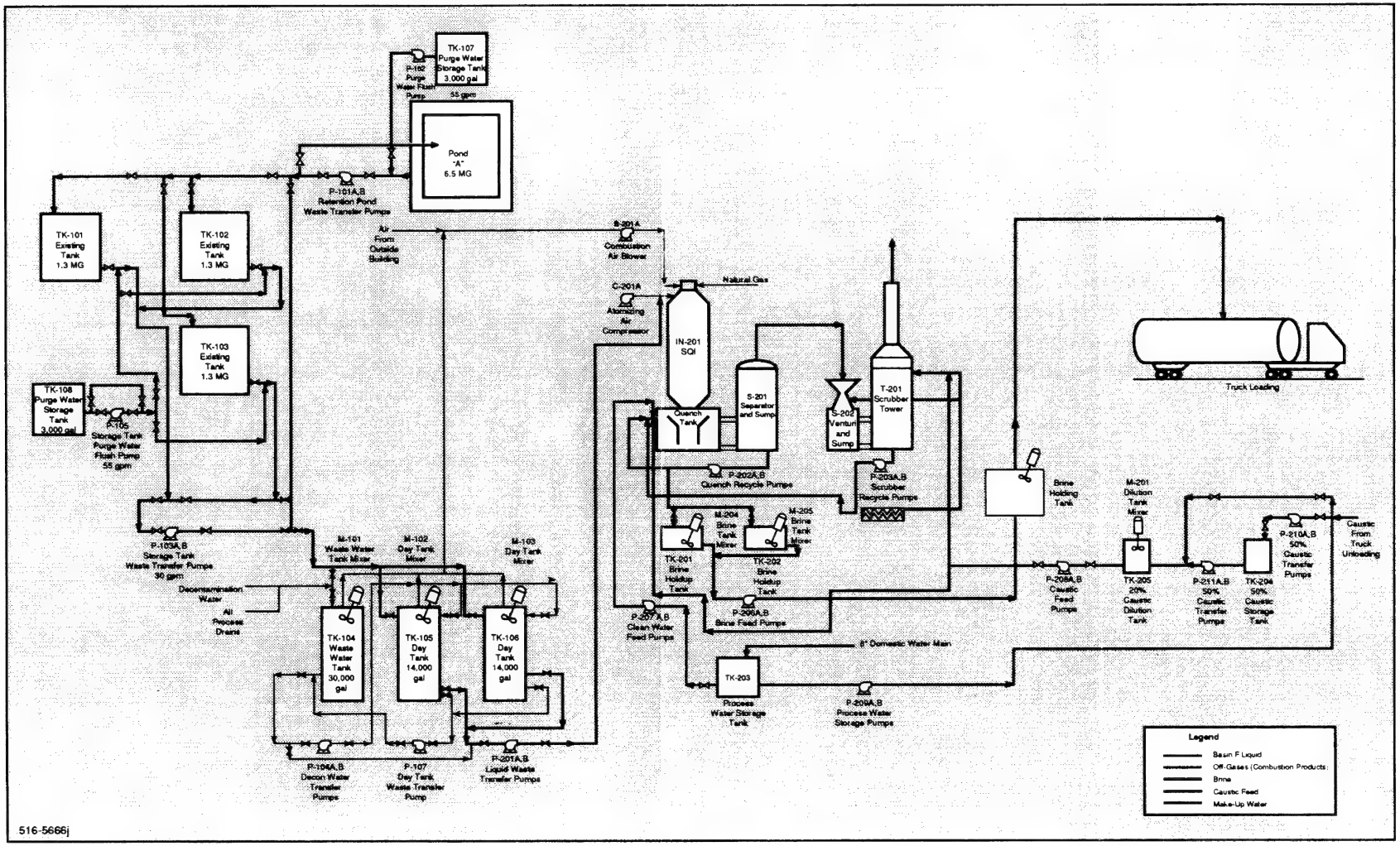
2.2 FACILITY DESCRIPTION

Submerged quench incineration has been selected to destroy the 10.5 million gallons of stored liquid from Basin F at RMA part of the Basin F IRA. The SQI consists of a feed system to inject the Basin F liquid into the incinerator, a high temperature incinerator with a quench chamber to cool the gases and dissolve the molten salts from combustion, a brine concentrator, and associated air pollution control equipment.

2.3 PROCESS DESCRIPTION

The submerged quench incineration process (see Figure 2-2) uses a vertical downfired liquid incinerator. The liquid to be incinerated is injected at the top of the furnace into a gas flame at high temperature (about 1,900°F). After incineration, all the combustion products are forced downward and cooled in a liquid quench tank to aid in washing out particulates and cleaning the exhaust gases. The high temperature has been found to destroy at least 99.99 percent of the organic compounds in the Basin F liquid. Noncombustible components of the Basin F liquid are melted, producing molten salts which flow down the walls of the incinerator and are cooled in a quench chamber. The exhaust gases, which will include a mixture of combustion byproducts and other gases, are passed through air pollution control devices, which include a venturi scrubber and a packed tower.

Complete incineration of all Basin F liquid will require the transportation into the RMA of an estimated 21,000 tons of a 50 percent solution of sodium hydroxide, a caustic compound used in the air pollution control process. The submerged quench incineration process will produce brine (containing the recovered salts) of about 2 times the original volume of the Basin F liquid. The brine, which contains metals, is transported off-site to a metals recycling



SUBMERGED QUENCH INCINERATOR
BASIN F
ROCKY MOUNTAIN ARSENAL
COMMERCE CITY, ADAMS COUNTY
COLORADO

FIGURE 2-2
PROCESS FLOW DIAGRAM OF THE SUBMERGED QUENCH INCINERATOR

RMAFG22A-K/DM-6/91

facility.

The facility is expected to operate for a period of 2 years, commencing in March 1993.

2.4 PHYSICAL CHARACTERISTICS AND OPERATING CONDITIONS

The as-built physical emission characteristics of the SQI are presented in Table 2-1 along with the operating conditions measured during the trial burn performed in June 1993. As discussed in Sections 5 and 6, the as-built SQI characteristics are essentially identical to the original design specifications. Miniburn results conducted in May 1993 provided essentially the same results (WESTON, 1993).

SECTION 2

CITED REFERENCES

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Table 2-1

Stack Characteristics of the SQI

Parameters	As-Built Parameters[a]
Base Elevation (m)	1,578
Stack Height (m)	30.48
Inside Diameter (m)	1.07
Exit Velocity (mps)	16.3
Exit Temperature (°K)	357

[a] As-built stack parameters obtained from trial burn test results, 12 June 1993.

SECTION 3

DESCRIPTION OF SURROUNDING AREA

3.1 INTRODUCTION

This section provides an overview of land use and population characteristics of the area around RMA that might be affected by emissions from the facility. The information compiled is important in identifying:

- Potentially exposed populations in areas affected by air dispersion or surface deposition of stack emissions.
- Population activities that need to be considered in determining both direct and indirect pathways of exposure to stack emissions.

Results of the air dispersion and surface deposition modeling isopleths (see Section 6) showed the area which might be affected by emissions was within a 10-km radius of the SQI. Therefore, the evaluation of land usage was focused on the areas within this radius predicted by the modeling to have the highest deposition and ambient air concentrations.

3.2 LOCATION AND GEOGRAPHY

The RMA, located in Adams County, Colorado, lies approximately 10 miles northeast of downtown Denver. The site occupies approximately 17,000 acres. RMA is bounded by East 96th Avenue on the north, Buckley Road on the east, East 56th Avenue on the south, Quebec Street on the west, and Highway 2 on the northwest. The landscape is generally flat and broad and is typical for high plains regions (Ebasco, 1990).

3.3 ON-SITE LAND AND WATER USE CHARACTERIZATION

3.3.1 On-Site Land Use

Compared to its former high level of activity, the RMA property can be viewed as an abandoned industrial site. RMA employed as many as 3,000 people when it was a fully operable production facility for chemicals, explosives, agricultural chemicals, and pesticides. Currently there is relatively little activity on the base. The primary activities that do occur involve administration, maintenance of the facility, and remediation.

The current land uses at the RMA site are classified as light industrial/commercial and recreational. The light industrial/commercial uses include: an army administration building, fire department, groundwater treatment facilities, rail classification yard, and a post office. Recreational uses include limited "catch and release" fishing (Ebasco, 1990) at several lakes on the site. The greatest proportion of acreage at the site is classified as a natural habitat for wildlife, which includes a bald eagle management area on the northwestern section (Ebasco, 1990).

3.3.2 Restrictions Limiting On-Site Land Use

As a result of the Superfund Amendments and Reauthorization Act (SARA) of 1986, an agreement was made among EPA Region VIII, the U.S. Army, the U.S. Department of the Interior and Shell Oil Company. This agreement, called the Federal Facility Agreement and Land Use Considerations (EPA et al., 1989), set forth the following restrictions on RMA:

- The U.S. government will retain title to the arsenal.
- Residential development is prohibited.
- Wildlife habitat will be preserved and managed to protect endangered species.
- No major geophysical alterations can be made on-site.
- Fish may be caught, but fish consumption is prohibited.

3.3.3 On-Site Surface Water Use

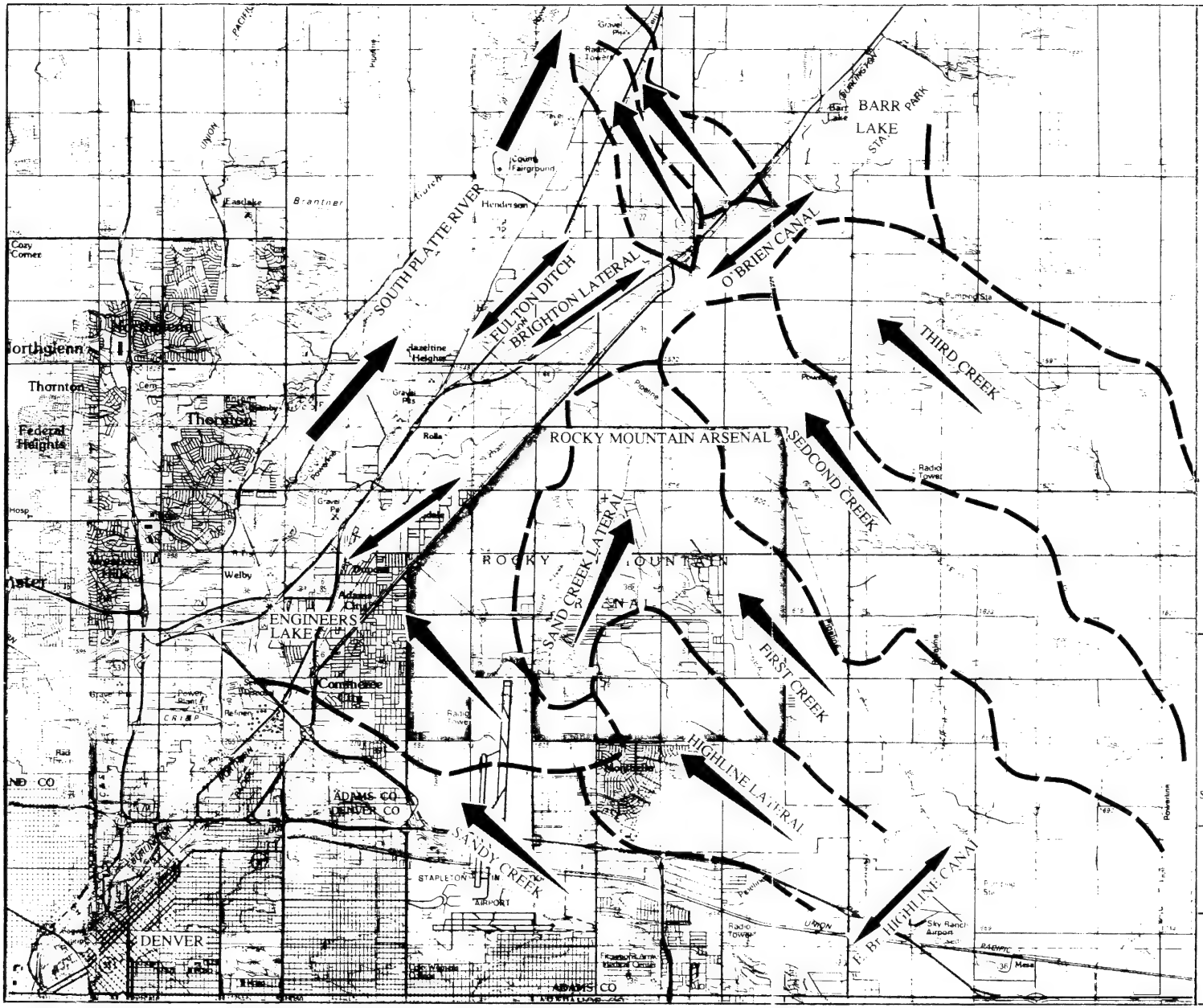
There are several lakes located on the southern sections of the arsenal: Upper Derby, Lower Derby, Mary, and Ladora Lakes. Ladora Lake is the only natural lake. The other lakes were created using water from the Highline Lateral. The Highline Lateral is an aqueduct that is connected to the main Highline Canal, which brings water from the Rocky Mountains into the Denver area.

Surface water drainage at RMA is a complicated process (see Figure 3-1); water on-site is primarily drained by the First Creek and Sand Creek Lateral. Water from the First Creek and Sand Creek Lateral is then intercepted by the O'Brian Canal and the Burlington Ditch. Both the O'Brian Canal and the Burlington Ditch then proceed to drain into the South Platte River. Both the O'Brian Canal and the Burlington Ditch are irrigation ditches, which transport water for agricultural purposes (ESE et al., 1989).

3.3.4 Restrictions Limiting On-Site Water Use

Drinking water uses of groundwater or surface water on-site are prohibited by the *Federal Facility Agreement and Land Use Considerations* (EPA et al., 1989). Presently, there are five groundwater treatment systems located on the northwestern side of the arsenal: Irondale, Northwest Boundary, North Boundary, Motor Pool/Railyard, and Basin A Neck systems. For safety reasons, the North and Northwest Boundary systems have a bedrock barrier, which separates treated from contaminated water.

There was only one water basin (Basin F) located on-site. Basin F was the only evaporative disposal system available at the facility. There are plans, however, to develop more basins and reservoirs for flood control and, thereby, to prevent contamination of water bodies off-site (Ebasco, 1990).



LEGEND:

SURFACE WATER DRAINAGE BOUNDARY (APPROXIMATE)

SURFACE WATER FLOW (GENERALIZED)

NORTH

5000 0 5000 10000

SCALE IN FEET

1000 500 0 1000 2000 3000 5000

SCALE IN METERS

SOURCE: BASE MAP ADAPTED FROM USGS 30x60 MINUTE SERIES, DENVER EAST AND DENVER WEST, COLORADO QUADS DATED 1981 AND 1983, RESPECTIVELY

SUBMERGED QUENCH INCINERATOR BASIN F
ROCKY MOUNTAIN ARSENAL
COMMERCE CITY, ADAMS COUNTY
COLORADO

FIGURE 3-1
GENERALIZED SURFACE WATER DRAINAGE IN THE VICINITY OF ROCKY MOUNTAIN ARSENAL

RMAFG31A.K.DM.6/91

3.4 OFF-SITE LAND AND WATER USE CHARACTERIZATION

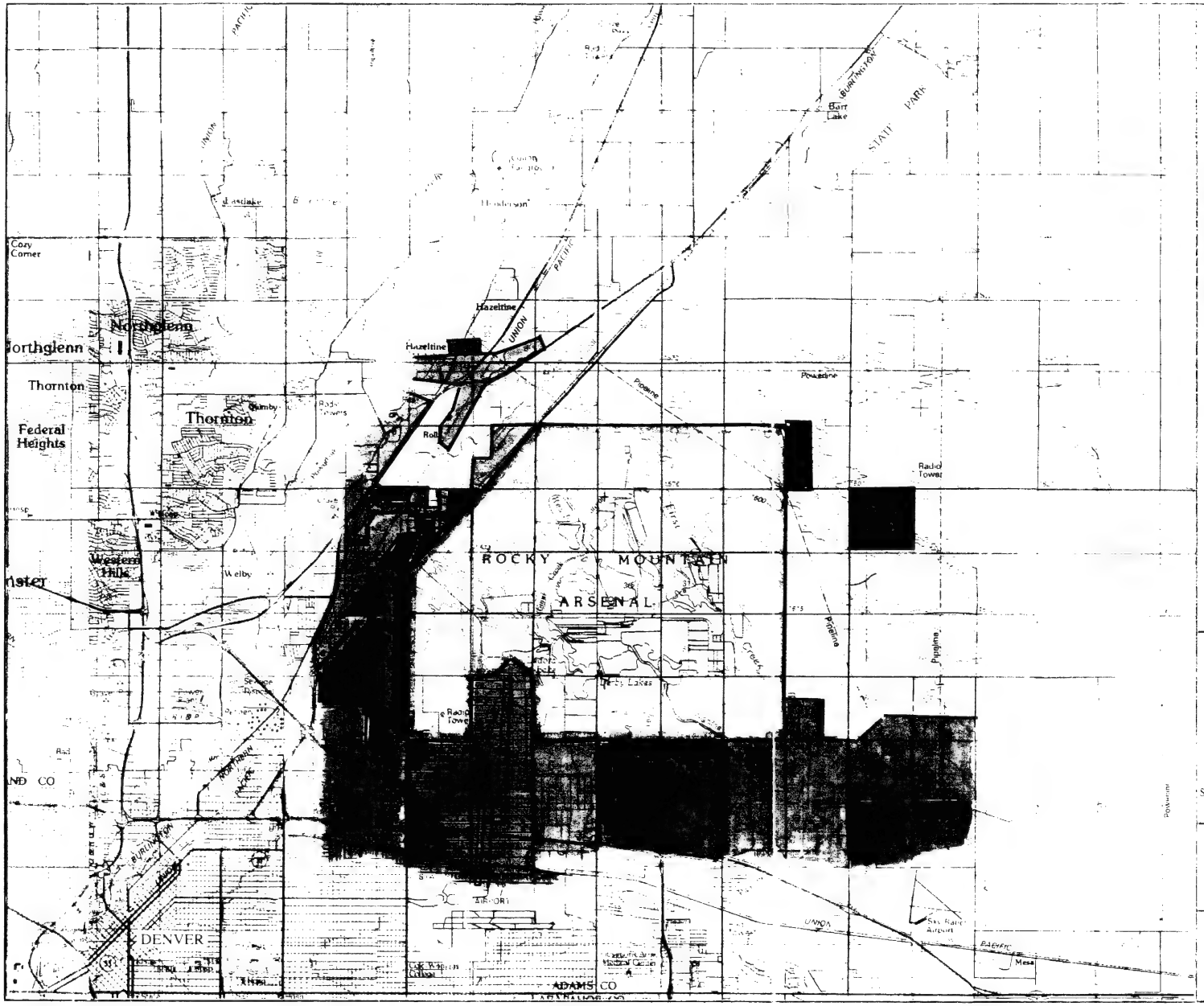
3.4.1 Off-Site Land Use

Land usage around RMA is characterized by a varied pattern of heavy and light industrial, residential, and agricultural designations (Figure 3-2). Agriculture predominates to the north and east, heavy industry to the west and south, and commercial uses primarily to the west. Residential areas are intermixed with commercial zones to the west and south. Commerce City, to the west, is associated with heavy industry, such as petroleum refineries, tank farms, and construction equipment yards. Gravel and sewage treatment facilities are located to the northwest, near the South Platte River.

The industry occupying the most acreage near RMA is Stapleton International Airport. This airport is the fifth largest in the United States and has grown rapidly. A new airport is under construction to the northeast of Denver. The new airport will not be in an area affected by emissions.

Several residential areas border the RMA property, primarily to the northwest, west, and south (e.g., Irondale, Commerce City, Dupont, Hanson, and Montbello). Adult, child, and infant activities associated with residences (e.g., outdoor play, school activities, and home gardening) have been documented previously (Woodward-Clyde, 1990) and were included in the identification of potential pathways of exposure for this risk assessment (Resident-A, Resident-B, and Farmer).

Since 1950, off-site agricultural land has been used primarily for grain crops, as temporarily idle fields, and, to a lesser extent, pasture lands. This area includes approximately 2,500 to 2,700 acres of irrigated farm land. Water for most of this land is supplied primarily by a combination of several irrigation ditches traversing certain areas just off-site (ESE et al., 1989).



LEGEND:

- AGRICULTURE
- RESIDENTIAL
- TRANSITIONAL
- COMMERCIAL/SERVICE
- INDUSTRIAL
- STAPLETON INTERNATIONAL AIRPORT

SOURCE: LAND USE DEVELOPED FROM EBASCO, 1990

NORTH

5000 0 5000 10000

SCALE IN FEET

1000 500 0 1000 2000 3000 5000

SCALE IN METERS

SOURCE: BASE MAP ADAPTED FROM USGS 30X60 MINUTE SERIES DENVER EAST AND DENVER WEST, COLORADO QUADS DATED 1981 AND 1983, RESPECTIVELY

SUBMERGED QUENCH INCINERATOR
BASIN F
ROCKY MOUNTAIN ARSENAL
COMMERCE CITY, ADAMS COUNTY
COLORADO

FIGURE 3-2
GENERALIZED LAND USE IN THE VICINITY OF ROCKY MOUNTAIN ARSENAL

RMAFG32A-KIDM 6-91

The primary field crops for this area are winter wheat, hay, barley, corn for grain and silage, sugar beets, and oats. Other crops grown include sorghum, dry beans, and spring wheat. Of the field crops listed, winter and spring wheat, barley, sugar beets, and dry beans are all produced for human consumption (ESE et al., 1989).

Pastureland and livestock are not as important to the rural agronomy as are the grain fields. Pastureland is confined to limited areas, most of which is contiguous to the O'Brian Canal and the Fulton Ditch (ESE et al., 1989).

In view of the large acreage of agricultural land north and east of the site, the possible existence of beef or dairy cattle farms was investigated. Information obtained from the Adams County Agricultural Extension Service suggested there were several feedlots and beef/dairy cattle operations within a 30-km radius of the incinerator. A tour by automobile of the northwestern, northern, and eastern perimeter of RMA in late October 1990 revealed six locations where cattle were observed grazing near farmhouses or on farmlands. No determination was made as to whether these were dairy or beef cattle.

3.4.2 Off-Site Surface Water Use

Off-site surface water use (i.e., potable water sources, recreational fisheries) was evaluated within a 20-km radius around the proposed incinerator site. The objective of this evaluation was to identify any possible uses of local off-site surface waters that should be considered as possible human exposure pathways (i.e., drinking water, fish ingestion). Consideration was given to the predicted level of surface deposition on the water body and associated watershed, as well as to the potential for surface water and soil runoff from the RMA site into these water bodies.

3.4.2.1 Classification of Rivers, Lakes, and Ponds as Potable Water Supplies

The Department of Natural Resources (DNR) Water Conservation Board, the DNR's State Engineering Board (Water Quality), water treatment plants in Adams County and Denver County, and the Denver Department of Health (Water Quality) were contacted to identify potable surface water sources. Those designated as potable water supplies were Standley Lake and Marston Lake Reservoir. These lakes and their associated watersheds are well beyond the range of significant aerial deposition predicted from emissions from the SQI. Standley Lake is over 16 km west of the incineration site, and Marston Lake Reservoir is located approximately 22 km southwest of the site. It is important to note that surface water drainage in this region is toward the northeast; drainage from RMA is directed to the South Platte River, which flows in a north-northeasterly direction (ESE et al., 1989). Therefore, it is unlikely that drainage from RMA would have any effect on potential drinking water sources such as Marston Lake Reservoir or Standley Lake.

3.4.2.2 Classification of Rivers, Lakes, and Ponds as Potential Fisheries

Potential fishing areas within the 10-km radius of the incinerator were evaluated initially from a review of the on-post (Ebasco, 1990) and off-post (ESE et al., 1989) human health exposure assessments. In addition, the DNR Fish and Game Department (Division of Wildlife) and local parks were contacted for fishing information.

Except for the limited "catch and release" fishing on-site at RMA, no lakes, ponds, or reservoirs were identified as designated fishing areas within a 5-km radius of the incinerator. However, several lakes and ponds designated as recreational fishing areas occur in the area between a 5- to 10-km radius of the incinerator.

The only lake located northeast of the arsenal is Barr Lake, a nonpotable water body, which is located approximately 6 km from the boundaries of RMA. Barr Lake is classified as a

wildlife refuge on its southern portion, and its northern half is used for recreational purposes, including fishing.

Four smaller water bodies located in Adams County, all approximately 8 km west of RMA, were identified as designated recreational fishing areas:

- Clear Creek Pond.
- Engineers Lake.
- Rotella Park Pond.
- Grandview Ponds 1 to 4.

Potential human exposure due to consumption of fish from these water bodies is evaluated in Section 7. Recreational uses are described in Appendix 3A.

3.5 CONCLUSIONS

The current major activities on-site are maintenance of the grounds and administrative functions. Off-site residential and agricultural uses (e.g., livestock, vegetables), land uses, and recreational (e.g., fishing) water uses have been documented. This information is used in the development of the human exposure pathways and scenarios (Sections 7 and 8).

SECTION 3

CITED REFERENCES

Ebasco Services Inc. 1990. *Final Human Health Exposure Assessment for the Rocky Mountain Arsenal. Volume I. Land Use and Exposed Populations*. Version 4.1. September 1990. Contract No. DAAA15-88-0024.

EPA (U.S. Environmental Protection Agency, Region VIII), U.S. Department of the Army, U.S. Department of the Interior, Rocky Mountain Region, and Agency for Toxic Substances and Disease Registry. 1989. *Federal Facility Agreement Pursuant to CERCLA Section 120*, Docket No. CERCLA VIII-89-13.

ESE (Environmental Science & Engineering, Inc.), Harding Lawson Associates, and Applied Environmental, Inc. 1989. *Technical Support for Rocky Mountain Arsenal. Offpost Operable Unit Endangerment Assessment/Feasibility Study with Applicable and Appropriate Requirements. Volume I. Draft Final Report Version 2.1*. March 1989. Contract No. DAAA15-88-D-0021.

Woodward-Clyde Consultants. 1990. *Draft Public Health Risk Assessment Report, Submerged Quench Incinerator, Task IRA-2, Basin F Liquids Treatment Design*. January 1990. Contract No. DAAA15-88-D-0022/0001, Version 2.1.

SECTION 4

THE PROCESS OF POLLUTANT IDENTIFICATION AND SELECTION

4.1 INTRODUCTION

The purpose of this section is to describe how the chemicals emitted from the SQI during the trial burn were identified and selected for evaluation. This differs from the objective of the 1991 risk assessment (WESTON, 1991) approach which was to conservatively estimate the types and numbers of pollutants that would theoretically be emitted based on SQI design characteristics, waste stream analyses, pilot test results and hazardous waste emissions inventories.

4.2 1993 RISK ASSESSMENT POLLUTANT IDENTIFICATION PROCESS

The trial burn data (10, 11, and 12 June 1993) were used to develop a list of pollutants and emissions rates. Methods used to evaluate the trial burn emissions data are identical to those established for analysis of the 100 percent miniburn as detailed in WESTON (1993). These methods are presented in Section 5 of this report. A list of the detected chemicals in the SQI stack samples is presented in Table 4-1. The current list has fewer chemicals than were predicted because a large number of chemicals were either not emitted in the trial burn test or could not be detected using the approved analytical protocols.

To insure that the detection limits were sensitive enough to measure potentially toxic chemical concentrations in the stack, a risk evaluation of the detection limits was performed (WESTON, 1993). It was concluded from this study that if all predicted chemicals were present at their detection limit concentrations, the total cancer and noncancer risk (based on the assumptions used in 1991) would be several orders of magnitude lower than the risk benchmark of 1E-06 (cancer) and a hazard index of one (noncancer).

Several acid and criteria gas emission rates were determined from continuous emission monitoring (CEM) data. These included carbon monoxide, nitrogen oxides (NO_x), and sulfur dioxide.

A number of compounds identified as possible release products in the 1991 risk assessment were not measured in the trial burn for one or more of the following reasons (refer to Sections 5 and 10 for a detailed discussion and listing):

1. There was no EPA validated sampling method.
2. The compound could not be analyzed in the laboratory due to methodological restrictions.
3. The compound was not judged to be significantly toxic to warrant analysis.

Most of the chemicals in this omitted group were noncarcinogens. None of these chemicals would likely pose a significant cancer or noncancer risk, based on the analysis presented in Section 10.

The list of pollutants selected from the trial burn for analysis are presented in Table 4-1.

SECTION 4

CITED REFERENCES

WESTON (Roy F. Weston, Inc.). 1991. *Final Draft Human Health Risk Assessment*. July 1991.

WESTON (Roy F. Weston, Inc.). 1993. *Evaluation of Analytical Detection Limits for the SQI*. June 1993.

Table 4-1

List of Pollutants Selected for Analysis in the Final 1993 Human Health Risk Assessment

Organics	Inorganics
Benzene	Aluminum
Benzoic Acid	Antimony
Bis(2-ethylhexyl)phthalate	Arsenic
Bromodichloromethane	Barium
Butylbenzylphthalate	Boron
Carbon Tetrachloride	Cadmium
Chlorobenzene	Chromium III
Chloroform	Chromium VI
Dibromochloromethane	Copper
Di-n-Butylphthalate	Iron
Diethylphthalate	Lead
Dimethylphthalate	Manganese
Dioxins/Furans (EPA TEFs)	Mercury
Heptachlor epoxide	Molybdenum
Methyl chloride	Nickel
Methylene chloride	Silver
Styrene	Tin
Toluene	Titanium
Xylenes	Vanadium
	Zinc
	Criteria Pollutants/Acid Gases
	Hydrogen Chloride
	Hydrogen Fluoride
	Nitrogen Oxides
	Sulfur Dioxide
	Carbon Monoxide
	Particulate matter

SECTION 5

DETERMINATION OF EMISSION RATES

5.1 INTRODUCTION

The purpose of this section is to summarize the results of the trial burn and describe how mass emission rates were developed for use in the risk assessment. A summary of the trial burn results is shown in Table 5-1. For comparison purposes, Table 5-1 also provides the values predicted for these compounds in the 1991 risk assessment (WESTON, 1991).

5.2 DATA TREATMENT

Treatment of nondetects (analytical results for which the concentration of the species of interest is below the detection limit of the method) and blank values was of critical importance because detection levels and blank concentrations were often the same order of magnitude as sample values. This sub-section describes the techniques that WESTON used for handling blank and nondetect values in the development of emission rates.

5.2.1 Treatment of Detects and Nondetects

The discussion presented below explains how averages, sums, confidence limits, and reported emission values have been calculated for all chemical species given various combinations of detected and nondetected values. The WESTON quantitation limit (WQL) defined the sample quantitation limit and provided the reference point from which nondetects (ND) and "J" values were determined (WESTON, 1993a). Two circumstances were considered for each potential scenario. The first arose when sample fractions or tube pairs were combined to develop values for an individual test run. The second resulted from averaging these individual test runs to develop a series or test method average.

5.2.1.1 All Values Detected

The arithmetic average or sum of the individual sample fractions was calculated, as appropriate. Both the maximum detected value and the 95 percent upper confidence limit (UCL) of the mean were calculated for the sample set for each compound. In accord with U.S. EPA guidance (EPA 1989), the lower of these two values was used in the risk assessment to estimate exposure point concentrations for each chemical.

5.2.1.2 All Values Below the Detection Limit

For individual test runs for a chemical, the analytical results were reported as "ND" when a single laboratory value was reported, or as "ND <" when multiple fractions or tube pairs were considered. When all three test runs of the trial burn were below the detection limit, the average was reported in the trial burn report as "ND". Chemicals not detected in any of the samples were eliminated from further consideration in the risk assessment.

5.2.1.3 Some Values Detected and Some Not Detected

When some test runs for a given chemical showed nondetects and some showed detects, half of the detection limit for nondetect values and the actual values for detects were used to calculate averages and confidence limits for a given chemical. This approach is in accord with EPA Risk Assessment Guidance for Superfund (EPA, 1989). As an example of the first circumstance, when summing (such as for mercury fractions), individual species values of 50, ND < (1), and ND < (2), the values would be summed as follows: $50+0.5+1$, or 51.5. The reported value would be $51.5 \div 3$, or 17.2. In reporting these types of sums or averages, no "<" sign was used. The only exception to this rule occurred when the average was less than the highest detection limit of the nondetected values. In this case, the average was reported as "ND < (the highest detection limit)". For example, the average for a Method 0030 test run with tube pair values of 5, ND < (4) and ND < (1) would be reported as "ND < (4)".

As an example for the second circumstance, an average for three test runs with results of 10, 8 and ND < (6) would be 7. In the event that three test run values of "ND <" were averaged, the reported result was "ND" as discussed previously in this sub-section.

These techniques used for calculating averages within a sample set caused complications when attempting to determine the 95 percent UCLs and maximum values (MAX). In the first case, which was discussed earlier in this subsection, where three test run values of "ND <" were considered to yield an average of ND, the compound was not considered in the risk assessment and therefore the UCL/MAX was presented as ND also. The second case involved the combination of "ND <" values and detected values. In this case, if the calculated average was ND < (highest detection limit) or a "real value", then the maximum was calculated in the normal fashion taking into account both the detected values and the "ND <" values. The UCL in this case was calculated based on the average of the detected values and one-half of the "ND <" values. For example, if the results of three test runs were 8, ND <9 and 6, then the average would be reported as ND < 9, the MAX would be ND < 9 and the UCL would be calculated as ND < 9.13. Thus, due to the methodology discussed previously, the reported UCL/MAX would be the lower of the two values (ND < 9). However, if the calculated UCL was lower than the presented average value, then the UCL/MAX value was defaulted to the maximum value. This situation would arise if the results of three test runs were ND < 4, 3, ND < 5. The reported average would be ND < 5, the MAX would also be ND < 5, and the calculated UCL would be 4.59. Due to the established methodology, the reported UCL/MAX would be ND < 5.

5.2.2 Values Outside the Calibration Range

In several cases, the value measured in the laboratory was outside the calibration range of the instrument. Data reported below the lower detection limit was flagged with the qualifier "J". Data with the "J" flag have been tentatively identified and tentatively quantified. Data reported above the upper quantitation limit were flagged with the qualifier "E". Data with the "E" flag have been positively identified and tentatively quantified. Data with either

qualifier are considered estimates, but both types of values were used without adjustment when calculating averages and confidence limits.

5.2.3 Blank Values

The level and treatment of blank values were important in interpreting data, since in some cases chemicals were detected in stack samples, but not at levels significantly higher than blanks. In these cases measured values may not have been representative of emissions, but rather limitations of the method.

5.2.3.1 Common Laboratory Contaminants

There are a number of chemicals that are common laboratory contaminants and which are frequently detectable in blanks. The EPA specifically lists acetone, 2-butanone (methyl ethyl ketone), methylene chloride, toluene, and phthalate esters in this category. According to standard EPA guidance (EPA, 1989), such chemicals may be treated as nondetects if the highest value in any sample is less than ten times the value in the highest blank. Therefore, the levels of these chemicals which were detected in stack samples were compared to the level in the appropriate blank. The results are shown in Table 5-2. As the table shows, none of these chemicals meet EPA's criterion for exclusion except bis(2-ethylhexyl)phthalate. However, because the other phthalates were not excluded, bis(2-ethylhexyl)phthalate was also retained for evaluation in the risk assessment in order to be maximally conservative.

5.2.3.2 Other Blank Contaminants

Standard EPA guidance (EPA, 1989) also allows for exclusion of other chemicals if the highest level detected in any sample is less than five times the highest blank value. Comparison of blanks with samples revealed that several chemicals could be excluded on this basis, including benzoic acid, aluminum, antimony, boron, tin, and chromium(VI).

However, in the interests of maintaining a maximally conservative overall approach to the risk assessment, none of these chemicals were excluded.

5.2.3.3 Blank Correction

For all chemicals included in the risk assessment, blanks were subtracted from respective sample train values. Laboratory and site/reagent blanks were analyzed and the results evaluated for identification of contamination. If a sample compound was corrected by the blank train, the data item was flagged by a B. If the value was blank train corrected to the detection limit, the value was reported as "ND < (the highest detection limit) B."

In cases where a blank value exceeded the level found in a sample, the sample value was corrected to the detection limit "ND< (the highest detection limit)" and flagged with a "BC." The "BC" signifies that the compound was detected in higher concentrations in the blank than in the sample.

5.2.4 Silicon

Silicon is oxidized during incineration and is emitted in the form of silica ($Si0_2$) by the SQI. Attempts were made to measure silica in stack samples, but very high levels were encountered both in samples and the blank. The data are as follows:

Blank	110,274,000 μg
Sample 1	91,656,000 μg
Sample 2	90,455,000 μg
Sample 3	95,554,000 μg

The source of the silica in the blank and samples is not certain, but there are several likely sources, including fibers from quartz filters, particles from silica gel, contamination from

stop-cock grease, and leaching from borosilicate glass impingers and containers. Regardless of the source, it is apparent that the silica measurements cannot be considered reliable.

For example, if stack samples really contained as much silica as indicated in the measurements (an approximate emission rate of 1.6E+02 g/sec), the total mass of particulate matter emitted would be expected to be about 620 times greater than what was actually measured (emission rate of 2.6E-01 g/sec). Also note that the emission rate for silicon predicted in the 1991 risk assessment was about 6.0E-03 g/sec (WESTON, 1991), which is approximately 28,000 times less than what was actually measured in the trial burn. These findings support the view that the mass of silica measured during the SQI trial burn is likely an artifact due to sampling methodology.

5.2.5 Summary of Data Treatment Methods

The 95 percent UCL (or the maximum value if lower than the UCL) of the arithmetic mean of the emission rate for each chemical was used to calculate ambient air and soil/water deposition concentrations. If all values in a set of emission data for a given chemical were nondetects, the chemical was not evaluated in the risk assessment. For those data sets with a combination of detects (or "J" values) and nondetects, the techniques described in this section were utilized to calculate the average and 95 percent UCL/Maximum.

5.3 TEST RESULTS

The EPA sampling and analytical methods used for the trial burn test program consisted of the following:

- Method 0050 - Particulate/HCl/HNO_3/HF
- Method 0030 - Volatile Organics
- Method 0010 - Semi-volatile Organics
- Method 23 - PCDD/PCDF
- Method 29 - Multi-metals
- Hexavalent Chromium

A series of three (3) test runs was performed for each sampling method. A set of six (6) tube pairs was collected for each of the Method 0030 test runs. A summary of all chemicals detected at least once for each sampling method is presented in Table 5-1. For comparison, the original predicted values from the July 1991 Draft Final Risk Assessment document are also shown. Detailed summaries for each sampling method encompassing all analyzed compounds (both detected and nondetected values) are presented in Tables 5-3 to 5-8.

A comparison of the trial burn emission rates with the 1991 predicted emission rates (see Table 5-1) reveals that most of the compounds detected in the trial burn were predicted in the 1991 document. Measured emission rates ranged from well below to well above the predicted rates. Several chemicals were detected in the trial burn that were not originally evaluated in the 1991 predicted risk analysis. These compounds include:

- Bromodichloromethane
- Dimethylphthalate
- Di-n-butylphthalate
- bis(2-Ethylhexyl)phthalate
- Dibromochloromethane
- Diethylphthalate
- Butylbenzylphthalate
- Heptachlor epoxide

The origin of these chemicals is not clear because some were not detected in the Basin F liquid, and therefore it is not expected that they would be present in the stack gas. In particular, the presence of the five phthalates is suspect because these are very common laboratory contaminants, and several of the phthalates were detected in blank samples. Nevertheless, all of these chemicals were assumed to be authentic release products and were evaluated in the risk assessment.

Carbon tetrachloride and chlorobenzene were added as internal standards ("spikes") to the test runs for volatiles (VOST; Table 5-1). The presence of these two compounds in the VOST results is very likely due to their direct addition to the waste stream during the test. This conclusion is supported by a comparison of spiked versus non-spiked runs performed during the 100 percent miniburn, where these two compounds were not detected in the non-

spiked runs (WESTON, 1993b). Nevertheless, in order to be conservative, both carbon tetrachloride and chlorobenzene were treated as authentic release products and were included in the risk assessment.

Table 5-9 summarizes emission rates for those gases that were sampled during continuous emission monitoring (CEM).

SECTION 5

CITED REFERENCES

EPA (U.S. Environmental Protection Agency) 1989. *Risk Assessment Guidance for Superfund. Volume I - Human Health Evaluation Manual (Part A)*. Interim final, OERR, Washington, D.C. EPA/540/1-89/002, December 1989.

WESTON (Roy F. Weston, Inc.) 1991. *Final Draft Human Health Risk Assessment,* July 1991.

WESTON (Roy F. Weston, Inc.) 1993a. *Evaluation of Detection Limits for the SQI Trial Burn Data: Treatment in Final Human Health Multipathway Risk Assessment*, 30 June 1003.

WESTON (Roy F. Weston, Inc.) 1993b. *Evaluation of Miniburn Test Data for the SQI*, Support of Interim Operations, 23 June 1993.

TABLE 5-1
ROCKY MOUNTAIN ARSENAL (RMA)
SUBMERGED QUENCH INCINERATOR
DENVER, CO

SUMMARY OF DETECTED COMPOUNDS IN THE TRIAL BURN AND
THE 1991 PREDICTED EMISSION RATES

POLLUTANT	EMISSION RATE, g/sec		
	TRIAL BURN [a]		1991 PREDICTED [b]
Trial Burn Metals			
Aluminum(Al)		3.74E-04	6.49E-04
Antimony (Sb)		2.06E-05	2.28E-05
Arsenic (As)	ND < [c]	7.42E-05	1.29E-04
Barium(Ba)	ND <	1.48E-04	3.16E-05
Boron(B)		6.90E-04	9.63E-04
Cadmium (Cd)	ND <	3.79E-06	2.02E-05
Calcium(Ca)	ND <	3.70E-03	2.02E-05
Chromium (Cr)	ND <	7.36E-06	8.88E-06
Copper(Cu)		7.63E-03	1.21E-01
Iron(Fe)		1.69E-04	1.72E-03
Lead (Pb)		1.10E-04	4.05E-05
Manganese(Mn)		3.35E-05	2.22E-04
Mercury (Hg)		2.65E-04	3.57E-05
Molybdenum(Mo)	ND <	7.42E-05	3.97E-04
Nickel (Ni)	ND <	2.96E-05	1.03E-03
Silver(Ag)	ND <	7.36E-06	3.43E-06
Tin(Sn)		4.98E-05	2.91E-04
Titanium(Ti)	ND <	7.42E-05	2.20E-06
Vanadium(V)	ND <	3.70E-05	8.42E-05
Zinc(Zn)		1.91E-03	5.86E-04
Total 2,3,7,8-TCDD Equivalents		4.12E-12	3.55E-11
Particulate Matter		0.254	0.5000
HCl		0.039	0.1700
HF	ND <	0.0011	0.188
HNO_3	ND <	0.0011	0.140
SO_2		3.40	0.88
NO_x		1.21	1.16
CO		0.30	0.17
Cr^{+6}	ND <	1.56E-06	8.88E-06

TABLE 5-1 (cont.)
ROCKY MOUNTAIN ARSENAL (RMA)
SUBMERGED QUENCH INCINERATOR
DENVER, CO

SUMMARY OF DETECTED COMPOUNDS IN THE TRIAL BURN AND
THE 1991 PREDICTED EMISSION RATES

POLLUTANT	EMISSION RATE, g/sec		
	TRIAL BURN [a]		1991 PREDICTED [b]
POHC VOST Emissions [e]			
Carbon Tetrachloride		1.13E-05	1.56E-08
Chlorobenzene	ND <	1.10E-05	4.15E-09
VOST Emissions [f]			
Chloromethane (Methyl Chloride)		1.41E-04	2.53E-05
Methylene Chloride		3.83E-04	2.62E-07
Chloroform		1.96E-04	2.70E-08
Bromodichloromethane		4.30E-05	
Dibromochloromethane		7.99E-06	
Benzene		1.24E-05	1.37E-08
Toluene		2.61E-05	2.46E-09
Styrene		1.06E-04	2.54E-05
Xylenes(total)	ND <	1.08E-05	2.73E-08
Semivolatile Organic Compounds			
Benzoic acid		5.14E-05	1.27E-05
Dimethylpthalate	ND <	9.82E-06	
Diethylphthalate		2.59E-05	
Di-n-butylphthalate		2.93E-05	
Butylbenzylpthalate		1.37E-05	
bis(2-Ethylhexyl)phthalate		1.95E-05	
Organochlorine Pesticides/PCB Emissions			
Heptachlor epoxide		2.78E-07	

[a] Value shown is the upper 95th confidence limit of the mean or the maximum value (whichever is lower).
[b] Value shown is the predicted long-term average (base case) emission rate.
[c] The symbol "ND <" implies that the chemical was detected at least once, but the average was less then the detection limit of the highest non-detected value.
[d] Pollutant not sampled for during the Trial Burn.
[e] POHC is defined as Principle Organic Hazardous Constituents.
[f] VOST is defined as Volatile Organic Sampling Train.

Table 5-2

Comparison of Sample and Blank Values for Common Laboratory Contaminants

Chemical	Blank (ug/m^3)	Maximum Sample (ug/m^3)	Meets EPA Criterion for Exclusion?
Methylene chloride	146	1880	No
Toluene	ND	119	No
Dimethylphthalate	ND	5	No
Diethylphthalate	ND	9	No
Di-n-butylphthalate	2	32	No
Butylbenzyphthalate	ND	14	No
Bis(2-ethyl)phthalate	1552	51	Yes

TABLE 5–3
ROCKY MOUNTAIN ARSENAL (RMA)
SUBMERGED QUENCH INCINERATOR
DENVER, CO
TRIAL BURN RESULTS

SUMMARY OF PARTICULATE, HCl, Cr^{+6}, HF, AND HNO_3 EMISSIONS

TEST DATA:											
Test run number		1		2		3		Average		UCL/Max	
Test location		Incin. Stack		Incin. Stack		Incin. Stack					
Test date		06–10–93		06–11–93		06–12–93					
Test time		0745–1041		0843–1341		0756–1047					
PARTICULATE EMISSIONS:											
Concentration, mg/dscm		55.94		68.17		59.63		61.25		68.17	
Concentration, mg/dscm @7% O_2		44.50		54.45		47.86		48.94		54.45	
Concentration, mg/dscm @12% CO_2		66.46		82.39		71.05		73.30		82.39	
Mass rate, g/sec		0.207		0.254		0.219		0.226		0.254	
HCl EMISSIONS:											
Concentration, mg/dscm		4.34		10.50		8.57		7.81		10.50	
Concentration, ppm/v		2.86		6.93		5.66		5.15		6.93	
Mass rate, g/sec		0.016		0.039		0.031		0.029		0.039	
Cr^{+6} EMISSIONS:											
Concentration, µg/dscm		0.206		0.038	ND <	0.435	ND <	0.435	ND <	0.435	
Mass rate, g/sec		7.07E–07		1.39E–07	ND <	1.56E–06	ND <	1.56E–06	ND <	1.56E–06	
HF EMISSIONS:											
Concentration, µg/dscm	ND <	315.5	ND <	305.9	ND <	310.7	ND <	310.7	ND <	315.5	
Mass rate, g/sec	ND <	0.0012	ND <	0.0011	ND <	0.0011	ND <	0.0011	ND <	0.0012	
HNO_3 EMISSIONS:											
Concentration, µg/dscm	ND <	305.9	ND <	296.3	ND <	301.1	ND <	301.1	ND <	305.9	
Mass rate, g/sec	ND <	0.0011	ND <	0.0011	ND <	0.0011	ND <	0.0011	ND <	0.0011	

TABLE 5–4
ROCKY MOUNTAIN ARSENAL (RMA)
SUBMERGED QUENCH INCINERATOR
DENVER, CO
TRIAL BURN RESULTS

SUMMARY OF VOLATILE ORGANIC (VOST) EMISSIONS

TEST DATA:	1		2		3		AVERAGE	UCL/MAX
Test run number	1		2		3		RUNS 1–3	RUNS 1–3
Test location	INCIN. STACK		INCIN. STACK		INCIN. STACK			
Test date	06–10–93		06–11–93		06–12–93			
Test time	0808–1109		0738–1047		0830–1124			
	µg/dscm	g/sec	µg/dscm	g/sec	µg/dscm	g/sec	g/sec	g/sec
POHC VOST EMISSIONS								
Carbon Tetrachloride	ND < 2.84	ND < 1.04E–05	3.04	1.13E–05	ND < 3.02	ND < 1.12E–05	ND < 1.12E–05	1.13E–05
Chlorobenzene	1.10	4.03E–06	ND < 2.90	ND < 1.08E–05	ND < 2.95	ND < 1.10E–05	ND < 1.10E–05	ND < 1.10E–05
VOST EMISSIONS								
Chloromethane (Methyl Chloride)	16.91	6.21E–05	13.90	5.18E–05	38.01	1.41E–04	8.51E–05	1.41E–04
Bromomethane (Methyl Bromide)	ND < 5.67	ND < 2.08E–05	ND < 5.94	ND < 2.22E–05	ND < 5.99	ND < 2.23E–05	ND	ND
Vinyl Chloride	ND < 5.59	ND < 2.05E–05	ND < 5.82	ND < 2.17E–05	ND < 5.91	ND < 2.20E–05	ND	ND
Chloroethane (Ethyl Chloride)	ND < 5.59	ND < 2.05E–05	ND < 5.82	ND < 2.17E–05	ND < 5.91	ND < 2.20E–05	ND	ND
Methylene Chloride (1)	101.97	3.74E–04	88.45	3.30E–04	102.94	3.83E–04	3.62E–04	3.83E–04
Carbon Disulfide	ND < 2.84	ND < 1.04E–05	ND < 2.93	ND < 1.09E–05	ND < 3.02	ND < 1.12E–05	ND	ND
1,1–Dichloroethene	ND < 2.79	ND < 1.03E–05	ND < 2.91	ND < 1.09E–05	ND < 2.96	ND < 1.10E–05	ND	ND
1,1–Dichloroethane	ND < 2.79	ND < 1.03E–05	ND < 2.91	ND < 1.09E–05	ND < 2.96	ND < 1.10E–05	ND	ND
1,2–Dichloroethene (total)	ND < 2.79	ND < 1.03E–05	ND < 2.91	ND < 1.09E–05	ND < 2.96	ND < 1.10E–05	ND	ND
Chloroform	41.68	1.53E–04	50.27	1.87E–04	52.82	1.96E–04	1.79E–04	1.96E–04
1,2–Dichloroethane (EDC)	ND < 2.79	ND < 1.03E–05	ND < 2.91	ND < 1.09E–05	ND < 2.96	ND < 1.10E–05	ND	ND
1,1,1–Trichloroethane (TCA)	ND < 2.79	ND < 1.03E–05	ND < 2.97	ND < 1.11E–05	ND < 2.96	ND < 1.10E–05	ND	ND
Bromodichloromethane	8.99	3.30E–05	10.34	3.86E–05	11.56	4.30E–05	3.82E–05	4.30E–05
1,2–Dichloropropane	ND < 2.79	ND < 1.03E–05	ND < 2.91	ND < 1.09E–05	ND < 2.96	ND < 1.10E–05	ND	ND
cis–1,3–Dichloropropene	ND < 2.79	ND < 1.03E–05	ND < 2.91	ND < 1.09E–05	ND < 2.96	ND < 1.10E–05	ND	ND
Trichloroethene (TCE)	ND < 2.79	ND < 1.03E–05	ND < 2.91	ND < 1.09E–05	ND < 2.96	ND < 1.10E–05	ND	ND
Dibromochloromethane	1.55	5.67E–06	1.79	6.66E–06	2.15	7.99E–06	6.78E–06	7.99E–06
1,1,2–Trichloroethane	ND < 2.79	ND < 1.03E–05	ND < 2.91	ND < 1.09E–05	ND < 2.96	ND < 1.10E–05	ND	ND
Benzene	3.37	1.24E–05	ND < 2.91	ND < 1.09E–05	ND < 3.02	ND < 1.12E–05	ND < 1.12E–05	1.24E–05
trans–1,3–Dichloropropene	ND < 2.79	ND < 1.03E–05	ND < 2.91	ND < 1.09E–05	ND < 2.96	ND < 1.10E–05	ND	ND
Bromoform	ND < 2.79	ND < 1.03E–05	ND < 2.91	ND < 1.09E–05	ND < 3.02	ND < 1.12E–05	ND	ND
Tetrachloroethene (PCE)	ND < 2.79	ND < 1.03E–05	ND < 2.91	ND < 1.09E–05	ND < 2.96	ND < 1.10E–05	ND	ND
1,1,2,2–Tetrachloroethane	ND < 2.79	ND < 1.03E–05	ND < 2.91	ND < 1.09E–05	ND < 2.96	ND < 1.10E–05	ND	ND
Toluene	6.73	2.47E–05	6.62	2.47E–05	7.02	2.61E–05	2.52E–05	2.61E–05
Ethylbenzene	ND < 2.84	ND < 1.04E–05	ND < 2.91	ND < 1.09E–05	ND < 2.96	ND < 1.10E–05	ND	ND
Styrene	28.91	1.06E–04	25.02	9.33E–05	26.86	9.99E–05	9.97E–05	1.06E–04
Xylenes(total)	1.21	4.44E–06	ND < 2.90	ND < 1.08E–05	1.35	5.03E–06	ND < 1.08E–05	ND < 1.08E–05
Dimethyldisulfide	ND < 2.79	ND < 1.03E–05	ND < 2.91	ND < 1.09E–05	ND < 2.96	ND < 1.10E–05	ND	ND

ND = Compound not detected in sample.
ND < = Either not detected in sample train and identified in another test run, or test run values were less than blank train values and the detection limit is reported.
(1) Commonly used laboratory solvents detected in samples and blanks; reported values have been blank corrected.
(2) If a tube pair non–detect value is averaged with a tube pair detected value then half the detection limit is used for the tube pair non–detected value. If the average for the three tube pairs is less than the highest full detection limit of any single tube pair then the average is reported as ND < (highest detection limit for a tube pair). Detection limits are based on the sum of the front and back half tube fractions (ie. 50 or 100 ng).

TABLE 5–5
ROCKY MOUNTAIN ARSENAL (RMA)
SUBMERGED QUENCH INCINERATOR
DENVER, CO
TRIAL BURN RESULTS

SUMMARY OF SEMI–VOLATILE ORGANIC EMISSIONS

TEST DATA: Test run number Test location Test date Test time	1 INCIN. STACK 06–10–93 0745–1501		2 INCIN. STACK 06–11–93 0710–1258		3 INCIN. STACK 06–12–93 0756–1416		AVERAGE RUNS 1–3	UCL/MAX RUNS 1–3
	µg/dscm	g/sec	µg/dscm	g/sec	µg/dscm	g/sec	g/sec	g/sec
Semivolatile Organic Compounds								
Phenol	ND	ND	ND	ND	ND	ND	ND	ND
Bis (2–chloroethyl) ether	ND	ND	ND	ND	ND	ND	ND	ND
2–Chlorophenol	ND	ND	ND	ND	ND	ND	ND	ND
1,3–Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND
1,4–Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND
Benzyl alchohol	ND	ND	ND	ND	ND	ND	ND	ND
1,2–Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND
2–Methylphenol	ND	ND	ND	ND	ND	ND	ND	ND
bis–(2–Chloroisopropyl)ether	ND	ND	ND	ND	ND	ND	ND	ND
4–Methylphenol	ND	ND	ND	ND	ND	ND	ND	ND
N–Nitroso–Di–n–propylamine	ND	ND	ND	ND	ND	ND	ND	ND
Hexachloroethane	ND	ND	ND	ND	ND	ND	ND	ND
Nitrobenzene	ND	ND	ND	ND	ND	ND	ND	ND
Isophorone	ND	ND	ND	ND	ND	ND	ND	ND
2–Nitrophenol	ND	ND	ND	ND	ND	ND	ND	ND
2,4–Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND
Benzoic acid	ND < 13.46	ND < 4.88E–05	ND < 13.15	ND < 4.91E–05	14.09	5.14E–05	ND < 4.91E–05	5.14E–05
bis(2–Chloroethoxy)methane	ND	ND	ND	ND	ND	ND	ND	ND
2,4–Dichlorophenol	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4–Trichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	ND	ND	ND	ND	ND	ND	ND	ND
4–Chloroaniline	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorobutadiene	ND	ND	ND	ND	ND	ND	ND	ND
4–Chloro–3–methylphenol	ND	ND	ND	ND	ND	ND	ND	ND
2–Mehtylnapthalene	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorocyclopentadiene	ND	ND	ND	ND	ND	ND	ND	ND
2,4,6–Trichlorophenol	ND	ND	ND	ND	ND	ND	ND	ND
2,4,5–Trichlorophenol	ND	ND	ND	ND	ND	ND	ND	ND
2–Chloronapthalene	ND	ND	ND	ND	ND	ND	ND	ND
2–Nitroanaline	ND	ND	ND	ND	ND	ND	ND	ND
Dimethylpthalate	1.35	4.88E–06	ND < 2.63	ND < 9.82E–06	ND < 2.63	ND < 9.60E–06	ND < 9.82E–06	ND < 9.82E–06
Acenaphthylene	ND	ND	ND	ND	ND	ND	ND	ND
2,6–Dinitrotoluene	ND	ND	ND	ND	ND	ND	ND	ND
3–Nitroanaline	ND	ND	ND	ND	ND	ND	ND	ND
Acenapthene	ND	ND	ND	ND	ND	ND	ND	ND

TABLE 5–5 (cont)
ROCKY MOUNTAIN ARSENAL (RMA)
SUBMERGED QUENCH INCINERATOR
DENVER, CO
TRIAL BURN RESULTS

SUMMARY OF SEMI–VOLATILE ORGANIC EMISSIONS

TEST DATA:	1		2		3		AVERAGE	UCL/MAX
Test run number	STACK		STACK		STACK		RUNS 1–3	RUNS 1–3
Test location	06–10–93		06–11–93		06–12–93			
Test date	0808–1109		0738–1047		0830–1124			
Test time								
	µg/dscm	g/sec	µg/dscm	g/sec	µg/dscm	g/sec	g/sec	g/sec
Semivolatile Organic Compounds								
2,4–Dinitrophenol	ND	ND	ND	ND	ND	ND	ND	ND
4–Nitrophenol	ND	ND	ND	ND	ND	ND	ND	ND
Dibenzofuran	ND	ND	ND	ND	ND	ND	ND	ND
2,4–Dinitrotoluene	ND	ND	ND	ND	ND	ND	ND	ND
Diethylphthalate	2.42	8.78E–06	1.84	6.87E–06	7.11	2.59E–05	1.39E–05	2.59E–05
4–Chlorophenyl–phenylether	ND	ND	ND	ND	ND	ND	ND	ND
Fluorene	ND	ND	ND	ND	ND	ND	ND	ND
4–Nitroanaline	ND	ND	ND	ND	ND	ND	ND	ND
4,6–Dinitro–2–methylphenol	ND	ND	ND	ND	ND	ND	ND	ND
n–Nitrosodiphenylamine(1)	ND	ND	ND	ND	ND	ND	ND	ND
4–Bromophenyl–phenylether	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND
Pentachlorophenol	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene	ND	ND	ND	ND	ND	ND	ND	ND
Carbazole	ND	ND	ND	ND	ND	ND	ND	ND
Di–n–butylphthalate	8.08	2.93E–05	6.05	2.26E–05	6.85	2.50E–05	2.56E–05	2.93E–05
Fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	ND	ND	ND	ND	ND	ND	ND	ND
Butylbenzylpthalate	3.77	1.37E–05	3.68	1.37E–05	ND < 2.63	ND < 9.60E–06	1.07E–05	1.37E–05
3,3'–Dichlorobenzidine	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)anthracene	ND	ND	ND	ND	ND	ND	ND	ND
Chrysene	ND	ND	ND	ND	ND	ND	ND	ND
bis(2–Ethylhexyl)phthalate	5.39	1.95E–05	3.16	1.18E–05	3.69	1.34E–05	1.49E–05	1.95E–05
Di–n–Octylphthalate	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(b)fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(k)fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	ND	ND	ND	ND	ND	ND	ND	ND
Indeno(1,2,3–cd)pyrene	ND	ND	ND	ND	ND	ND	ND	ND
Dibenzo(a,h)anthracene	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	ND	ND	ND	ND	ND	ND	ND	ND
Quinoline	ND	ND	ND	ND	ND	ND	ND	ND
4,4–Dichlorobiphenyl	ND	ND	ND	ND	ND	ND	ND	ND
Pentachlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND

TABLE 5–6
ROCKY MOUNTAIN ARSENAL (RMA)
SUBMERGED QUENCH INCINERATOR
DENVER, CO
TRIAL BURN RESULTS

SUMMARY OF PESTICIDE/PCB EMISSIONS

TEST DATA: Test run number Test location Test date Test time	1 INCIN. STACK 06–10–93 0745–1501		2 INCIN. STACK 06–11–93 0710–1258		3 INCIN. STACK 06–12–93 0756–1416		AVERAGE RUNS 1–3	UCL/MAX RUNS 1–3
	µg/dscm	g/sec	µg/dscm	g/sec	µg/dscm	g/sec	g/sec	g/sec
Organochlorine Pesticides/PCB Emissions								
Alpha–BHC	ND	ND	ND	ND	ND	ND	ND	ND
Beta–BHC	ND	ND	ND	ND	ND	ND	ND	ND
Delta–BHC	ND	ND	ND	ND	ND	ND	ND	ND
gamma–BHC	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND	ND	ND	ND	ND
Aldrin	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor epoxide	0.08	2.78E–07	ND < 0.03	ND < 9.82E–08	ND < 0.03	ND < 9.60E–08	1.25E–07	2.78E–07
Endosulfan I	ND	ND	ND	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND	ND	ND	ND
4,4'–DDE	ND	ND	ND	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND	ND	ND	ND
Isodrin	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan II	ND	ND	ND	ND	ND	ND	ND	ND
4,4'–DDD	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan sulfate	ND	ND	ND	ND	ND	ND	ND	ND
4,4'–DDT	ND	ND	ND	ND	ND	ND	ND	ND
Methoxychlor	ND	ND	ND	ND	ND	ND	ND	ND
Endrin ketone	ND	ND	ND	ND	ND	ND	ND	ND
alpha–Chlordane	ND	ND	ND	ND	ND	ND	ND	ND
gamma–Chlordane	ND	ND	ND	ND	ND	ND	ND	ND
Toxaphene	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor–1016	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor–1221	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor–1232	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor–1242	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor–1248	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor–1254	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor–1260	ND	ND	ND	ND	ND	ND	ND	ND

TABLE 5–6 (cont.)
ROCKY MOUNTAIN ARSENAL (RMA)
SUBMERGED QUENCH INCINERATOR
DENVER, CO
TRIAL BURN RESULTS

SUMMARY OF PESTICIDE/PCB EMISSIONS

TEST DATA: Test run number Test location Test date Test time	1 STACK 06–10–93 0808–1109		2 STACK 06–11–93 0738–1047		3 STACK 06–12–93 0830–1124		AVERAGE RUNS 1–3	UCL/MAX RUNS 1–3
	µg/dscm	g/sec	µg/dscm	g/sec	µg/dscm	g/sec	g/sec	g/sec
Organophosphorous Pesticides/ PCB Emissions Data								
Atrazine	ND	ND	ND	ND	ND	ND	ND	ND
Dichlorvos	ND	ND	ND	ND	ND	ND	ND	ND
Mevinphos	ND	ND	ND	ND	ND	ND	ND	ND
Ethoprop	ND	ND	ND	ND	ND	ND	ND	ND
Naled	ND	ND	ND	ND	ND	ND	ND	ND
Phorate	ND	ND	ND	ND	ND	ND	ND	ND
Demeton, O	ND	ND	ND	ND	ND	ND	ND	ND
Demeton, S	ND	ND	ND	ND	ND	ND	ND	ND
Diazinon	ND	ND	ND	ND	ND	ND	ND	ND
Disulfoton	ND	ND	ND	ND	ND	ND	ND	ND
Methyl Parathion	ND	ND	ND	ND	ND	ND	ND	ND
Ronnel	ND	ND	ND	ND	ND	ND	ND	ND
Malathion	ND	ND	ND	ND	ND	ND	ND	ND
Fenthion	ND	ND	ND	ND	ND	ND	ND	ND
Ethyl Prathion	ND	ND	ND	ND	ND	ND	ND	ND
Chlorpyrifos	ND	ND	ND	ND	ND	ND	ND	ND
Fensulfothion	ND	ND	ND	ND	ND	ND	ND	ND
Trichloronate	ND	ND	ND	ND	ND	ND	ND	ND
Merphos	ND	ND	ND	ND	ND	ND	ND	ND
Stirophos	ND	ND	ND	ND	ND	ND	ND	ND
Bolstar	ND	ND	ND	ND	ND	ND	ND	ND
Azinphos–methyl	ND	ND	ND	ND	ND	ND	ND	ND
Coumaphos	ND	ND	ND	ND	ND	ND	ND	ND
Supona	ND	ND	ND	ND	ND	ND	ND	ND
Tokuthion	ND	ND	ND	ND	ND	ND	ND	ND

TABLE 5-7
ROCKY MOUNTAIN ARSENAL (RMA)
SUBMERGED QUENCH INCINERATOR
DENVER, CO
TRIAL BURN RESULTS

SUMMARY OF DIOXIN/FURAN EMISSIONS

TEST DATA Test run number Test location Test date Test time period	1 INCIN. STACK 06-10-93 0745-1501		2 INCIN. STACK 06-11-93 0710-1258		3 INCIN. STACK 06-12-93 0756-1416		AVERAGE RUNS 1-3	UCL/MAX RUNS 1-3
	µg/dscm	g/sec	µg/dscm	g/sec	µg/dscm	g/sec	g/sec	g/sec
TOXICITY EQUIVALENCY EMISSIONS (I-TEFs/89)								
2,3,7,8-TCDD	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3,7,8-PeCDD	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3,4,7,8-HxCDD	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3,6,7,8-HxCDD	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3,7,8,9-HxCDD	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3,4,6,7,8-HpCDD	5.08E-08	1.86E-13	ND < 5.01E-08	ND < 1.88E-13	5.08E-08	1.84E-13	ND < 1.88E-13	ND < 1.88E-13
1,2,3,4,6,7,8,9-OCDD	1.02E-08	3.71E-14	7.52E-09	2.82E-14	1.78E-08	6.45E-14	4.33E-14	6.45E-14
Total TCDD	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00
Total PeCDD	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00
Total HxCDD	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00
Total HpCDD	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00
2,3,7,8-TCDF	5.08E-07	1.86E-12	5.01E-07	1.88E-12	ND < 2.54E-07	ND < 9.22E-13	1.40E-12	1.88E-12
1,2,3,7,8-PeCDF	ND	ND	ND	ND	ND	ND	ND	ND
2,3,4,7,8-PeCDF	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3,4,7,8-HxCDF	5.08E-07	1.86E-12	ND < 2.51E-07	ND < 9.41E-13	ND < 2.03E-07	ND < 7.38E-13	ND < 9.41E-13	1.86E-12
1,2,3,6,7,8-HxCDF	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3,7,8,9-HxCDF	ND	ND	ND	ND	ND	ND	ND	ND
2,3,4,6,7,8-HxCDF	ND < 5.08E-07	ND < 1.86E-12	5.01E-08	1.88E-13	ND < 2.54E-07	ND < 9.22E-13	ND < 1.86E-12	ND < 1.86E-12
1,2,3,4,6,7,8-HpCDF	5.08E-08	1.86E-13	2.51E-08	9.41E-14	ND < 2.54E-08	ND < 9.22E-14	1.09E-13	1.86E-13
1,2,3,4,7,8,9-HpCDF	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3,4,6,7,8,9-OCDF	ND	ND	ND	ND	ND	ND	ND	ND
Total TCDF	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00
Total PeCDF	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00
Total HxCDF	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00
Total HpCDF	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00
TOTAL 2,3,7,8-TCDD EQUIVALENTS	1.13E-06	4.12E-12	5.84E-07	2.19E-12	6.85E-08	2.49E-13	2.19E-12	4.12E-12

TABLE 5–8
ROCKY MOUNTAIN ARSENAL (RMA)
SUBMERGED QUENCH INCINERATOR
DENVER, CO
TRIAL BURN RESULTS

SUMMARY OF MULTI–METALS EMISSIONS

TEST DATA:	1		2		3		AVERAGE	UCL/MAX
Test run number	INCIN. STACK		INCIN. STACK		INCIN. STACK		RUNS 1–3	RUNS 1–3
Test location	06–10–93		06–11–93		06–12–93			
Test date	0745–1032		0710–0953		0756–1101			
Test time								
	µg/dscm	g/sec	µg/dscm	g/sec	µg/dscm	g/sec	g/sec	g/sec
TRIAL BURN METALS								
Antimony (Sb)	4.90	1.81E–05	5.38	1.99E–05	5.29	2.06E–05	1.95E–05	2.06E–05
Arsenic (As)	ND < 18.98	ND < 7.01E–05	5.46	2.01E–05	ND < 19.04	ND < 7.42E–05	ND < 7.42E–05	ND < 7.42E–05
Barium(Ba)	ND < 37.96	ND < 1.40E–04	18.43	6.80E–05	ND < 38.03	ND < 1.48E–04	ND < 1.48E–04	ND < 1.48E–04
Beryllium(Be)	ND < 0.97	ND < 3.58E–06	ND < 0.19	ND < 7.07E–07	ND < 0.97	ND < 3.79E–06	ND	ND
Cadmium (Cd)	0.78	2.87E–06	ND < 0.94	ND < 3.46E–06	ND < 0.97	ND < 3.79E–06	ND < 3.79E–06	ND < 3.79E–06
Chromium (Cr)	ND < 1.88	ND < 6.96E–06	1.35	5.00E–06	ND < 1.89	ND < 7.36E–06	ND < 7.36E–06	ND < 7.36E–06
Copper(Cu)	1793.85	6.62E–03	2067.22	7.63E–03	1731.95	6.75E–03	7.00E–03	7.63E–03
Lead (Pb)	26.49	9.78E–05	29.82	1.10E–04	26.01	1.01E–04	1.03E–04	1.10E–04
Mercury (Hg)	58.67	2.17E–04	52.27	1.93E–04	67.97	2.65E–04	2.25E–04	2.65E–04
Nickel (Ni)	ND < 7.58	ND < 2.80E–05	3.45	1.27E–05	ND < 7.61	ND < 2.96E–05	ND < 2.96E–05	ND < 2.96E–05
Selenium(Se)	ND < 18.98	ND < 7.01E–05	ND < 10.63	ND < 3.92E–05	ND < 19.04	ND < 7.42E–05	ND	ND
Silver(Ag)	1.53	5.65E–06	ND < 1.72	ND < 6.36E–06	ND < 1.89	ND < 7.36E–06	ND < 7.36E–06	ND < 7.36E–06
Thallium(Tl)	ND < 18.98	ND < 7.01E–05	ND < 16.03	ND < 5.92E–05	ND < 19.04	ND < 7.42E–05	ND	ND
Vanadium(V)	ND < 9.47	ND < 3.50E–05	1.12	4.15E–06	ND < 9.50	ND < 3.70E–05	ND < 3.70E–05	ND < 3.70E–05
Zinc(Zn)	245.94	9.08E–04	469.83	1.73E–03	490.55	1.91E–03	1.52E–03	1.91E–03
OTHER METALS								
Aluminum(Al)	78.46	2.90E–04	101.23	3.74E–04	68.03	2.65E–04	3.10E–04	3.74E–04
Boron(B)	103.10	3.81E–04	153.52	5.67E–04	177.21	6.90E–04	5.46E–04	6.90E–04
Calcium(Ca)	ND < 949.01	ND < 3.50E–03	140.71	5.20E–04	ND < 951.02	ND < 3.70E–03	ND < 3.70E–03	ND < 3.70E–03
Cobalt(Co)	ND < 9.47	ND < 3.50E–05	ND < 1.16	ND < 4.28E–06	ND < 9.50	ND < 3.70E–05	ND	ND
Iron(Fe)	45.87	1.69E–04	36.71	1.36E–04	40.20	1.57E–04	1.54E–04	1.69E–04
Lithium(Li)	ND < 18.98	ND < 7.01E–05	ND < 3.88	ND < 1.43E–05	ND < 19.04	ND < 7.42E–05	ND	ND
Manganese(Mn)	5.70	2.10E–05	4.50	1.66E–05	8.60	3.35E–05	2.37E–05	3.35E–05
Molybdenum(Mo)	ND < 18.98	ND < 7.01E–05	7.63	2.82E–05	ND < 19.04	ND < 7.42E–05	ND < 7.42E–05	ND < 7.42E–05
Tin(Sn)	12.32	4.55E–05	12.11	4.47E–05	12.78	4.98E–05	4.67E–05	4.98E–05
Titanium(Ti)	ND < 18.98	ND < 7.01E–05	2.58	9.54E–06	ND < 19.04	ND < 7.42E–05	ND < 7.42E–05	ND < 7.42E–05
Silicon (Si)	---	---	---	---	---	---	---**	---**

** Due to sample train methodology, this metal could not be accurately quantified.

TABLE 5–9
ROCKY MOUNTAIN ARSENAL (RMA)
SUBMERGED QUENCH INCINERATOR
DENVER, CO
TRIAL BURN RESULTS
SUMMARY OF CEM PARAMETERS IN THE TRIAL BURN

POLLUTANT [a]	AVERAGE				MAXIMUM				1991
	CONC. (ppm)	VOLUMETRIC FLOW RATE (dscfm)	EMISSION RATE (lb/hr)	EMISSION RATE (g/sec)	CONC. (ppm)	VOLUMETRIC FLOW RATE (dscfm)	EMISSION RATE (lb/hr)	EMISSION RATE (g/sec)	BASE CASE EMISSION (g/sec)
CO									
Run 1	49.5	7775	1.68	0.21	73.0	7775	2.47	0.31	
Run 2	47.4	7900	1.63	0.21	62.7	7900	2.16	0.27	
Run 3	57.6	7875	1.98	0.25	75.7	7875	2.60	0.33	
Average	**51.5**	**7850**	**1.76**	**0.22**	**70.5**	**7850**	**2.41**	**0.30**	**0.17**
SO_2									
Run 1	20.7	7775	1.60	0.20	503.4 [b]	7775	39.00	4.91	
Run 2	1.13	7900	0.09	0.01	32.7	7900	2.57	0.32	
Run 3	145	7875	11.38	1.43	501.9 [b]	7875	39.39	4.96	
Average	**55.6**	**7850**	**4.36**	**0.55**	**346.0**	**7850**	**26.99**	**3.40**	**0.88**
NO_x									
Run 1	119.2	7775	6.64	0.84	162.0	7775	9.02	1.14	
Run 2	142.0	7900	8.03	1.01	175.0	7900	9.90	1.25	
Run 3	130.7	7875	7.37	0.93	175.0	7875	9.87	1.24	
Average	**130.6**	**7850**	**7.35**	**0.93**	**170.7**	**7850**	**9.60**	**1.21**	**1.16**

[a] Concentrations determined by CEM located in the SQI stack (Trial Burn Report, Table 5–7). Volumetric flow rates based on an average of the isokinetic test runs.
[b] Concentration detected was greater than or equal to the full scale value of the respective instrument used during the test. The reported value is the full scale value.

SECTION 6

AIR QUALITY AND DEPOSITION MODELING ANALYSIS

6.1 INTRODUCTION

Based on the emission factors developed in Section 5, both ambient air concentrations and deposition rates to soil can be predicted. This section describes the models used, presents the modeling input data, explains the necessary modifications to determine dry and wet deposition, and presents a series of tables summarizing the results of the modeling analysis.

6.2 AIR QUALITY MODELING

The modeling procedure for the simple terrain analysis followed the recommended techniques described in *Guidance on Air Quality Models (Revised)*, dated July 1986 (EPA, 1986a).

The EPA UNAMAP VI version of the ISCST model was used to calculate ambient pollutant concentrations for all pollutants for the terrain surrounding the facility. The ISCST model was executed in the rural "regulatory" mode, which selects the appropriate constants and features to be consistent with the requirements defined in the *Guidance on Air Quality Models* (EPA, 1986a), including:

- Stack tip downwash.
- Final plume rise.
- Buoyancy-induced dispersion.
- Vertical potential temperature gradient.
- Treatment for calms.
- Wind profile exponents.

The air quality modeling utilized the following information: 5 years (1985-1989) of hourly meteorological data from Denver Stapleton International Airport; the emission

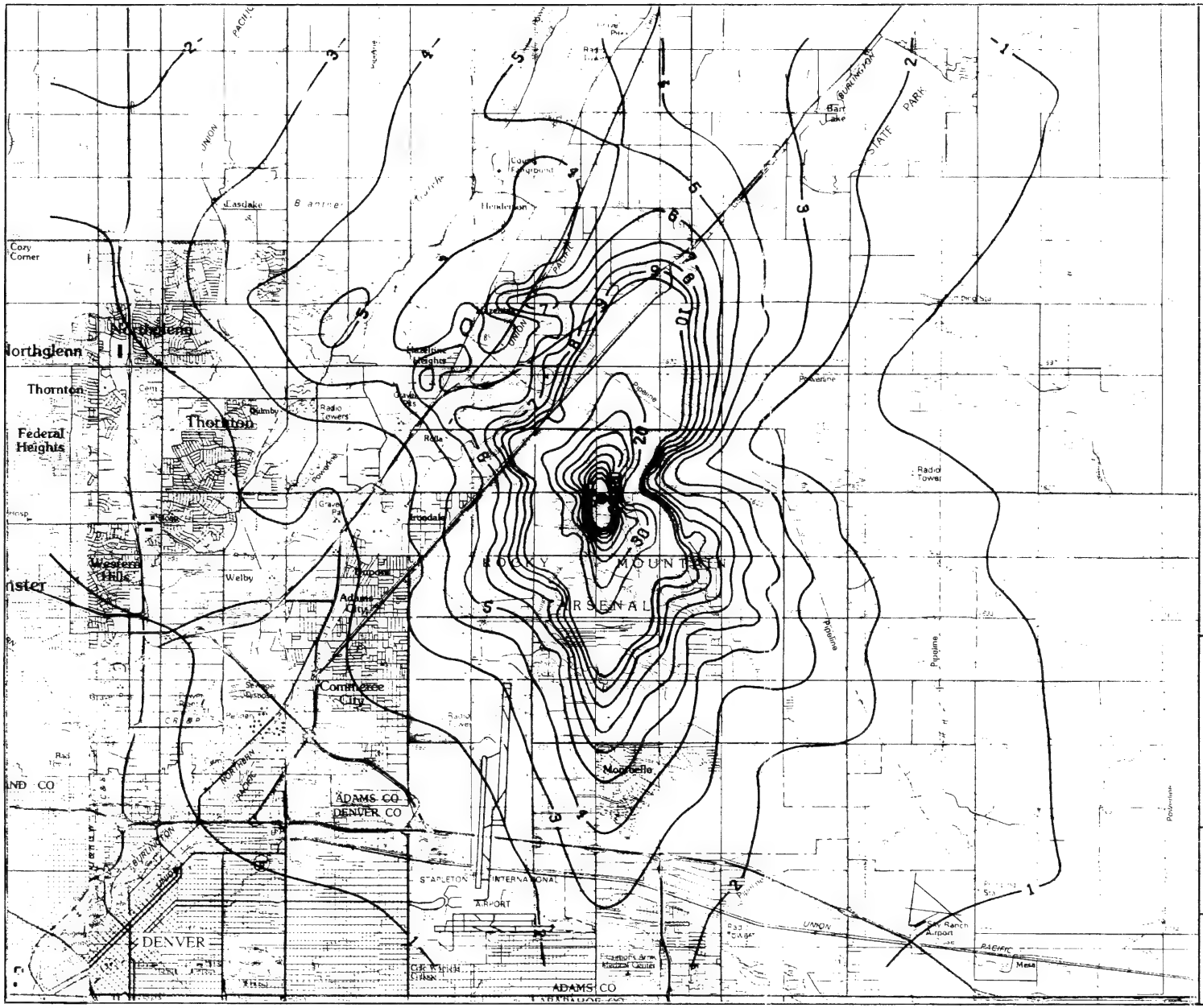
characteristics of the SQI facility stack shown in Table 6-1; a polar receptor grid network shown in Table 6-2 with terrain elevations; and the surface roughness for the area surrounding the arsenal to estimate the air quality impacts of the SQI facility. The modeling also incorporated the potential downwash effects of the SQI stack emissions due to the SQI buildings. A directional specific downwash analysis was performed for the stack and the building dimension for every 10-degree wind direction that was utilized in the air quality model. The estimated ambient air quality impacts (5-year average concentration isopleth) are presented in Figure 6-1. This figure contains the isopleth plot of estimated ambient concentrations.

6.3 DEPOSITION MODELING

In the past, health risk assessments for toxic pollutants emitted by hazardous waste incineration facilities have been limited to the inhalation pathway, based on predictions of ambient exposure levels using air quality dispersion models as described earlier. Recently, concerns about potential risks from indirect pathways have led to the necessity of conducting multipathway risk assessments. To conduct such studies, estimates of the rate of deposition over time for toxic pollutants emitted by such facilities are needed. The two major methods for the accumulation of materials in soils, water, and vegetation are dry and wet deposition. The methods used to estimate each of these processes are described in the subsections that follow.

6.3.1 Dry Deposition

Dry deposition is driven by atmospheric processes, the properties of the surfaces upon which materials deposit, and the properties of the particles being deposited. Previous studies of dry deposition have used only gravitational settling velocities to remove particles from the atmosphere. In particular, the EPA's Industrial Source Complex (ISC) model, which contains a gravitational algorithm, has been used in the past to calculate dry deposition. However, this model generally does not account for the properties of the particles deposited,


Legend:
2
ISOPLETH (µgm/m³)
FIVE YEAR AVERAGE CONCENTRATION
NORTH
5000 0 5000 15000
SCALE IN FEET
1000 500 0 1000 2000 3000 5000
SCALE IN METERS
SOURCE: BASE MAP ADAPTED FROM USGS 30x60 MINUTE SERIES DENVER EAST AND DENVER WEST, COLORADO QUADS DATED 1981 AND 1983, RESPECTIVELY
SUBMERGED QUENCH INCINERATOR
BASIN F
ROCKY MOUNTAIN ARSENAL
COMMERCE CITY, ADAMS COUNTY
COLORADO
FIGURE 6-1
FIVE YEAR AVERAGE CONCENTRATION
ISOPLETH (µgm/m³)
Northglenn
Thornton
Federal Heights
Commerce City
ROCKY MOUNTAIN ARSENAL
ADAMS CO
DENVER CO
DENVER
STAPLETON INTERNATIONAL AIRPORT
Welby
Montbello
Mesa

the surface properties that affect dry deposition, or the hourly meteorological effects other than stability.

Work by Sehmel and Hodgsen (1978) has resulted in a parameterization of the dry deposition process, taking more fully into account hourly meteorological conditions (e.g., wind speed, stability, etc.), particle properties (e.g., density, size), and the surface properties (e.g., surface roughness) upon which material is dry deposited.

The basic approach to dry deposition involves calculation of the ambient ground-level concentration and the deposition velocity. The deposition flux is given by:

$$-F = V_d * X_i$$

Where:

$-F$ = Downward flux of material deposited

V_d = Deposition velocity

X_i = Ambient concentration for pollutant i

Therefore, if an estimate of the deposition velocity and the ambient concentration for a pollutant can be made, the dry deposition flux can be calculated. Ransieri and Croes (1987) of the California Air Resources Board (CARB) have developed computer algorithms based on Sehmel and Hodgsen's work that provide hourly values of dry deposition velocity using preprocessed meteorologic data that can be obtained using the EPA preprocessor program.

WESTON has modified the EPA UNAMAP VI version of the ISCST model incorporating the CARB algorithms to calculate dry deposition. This model, which is known as the WESDEP model, calculates hourly ambient ground-level pollutant concentrations, as well as hourly deposition velocities, to predict the dry deposition flux at each receptor.

This model allows for building wake effects and terrain adjustments, and incorporates a separate surface roughness coefficient (Z_o) for each receptor. Source information required for the model includes:

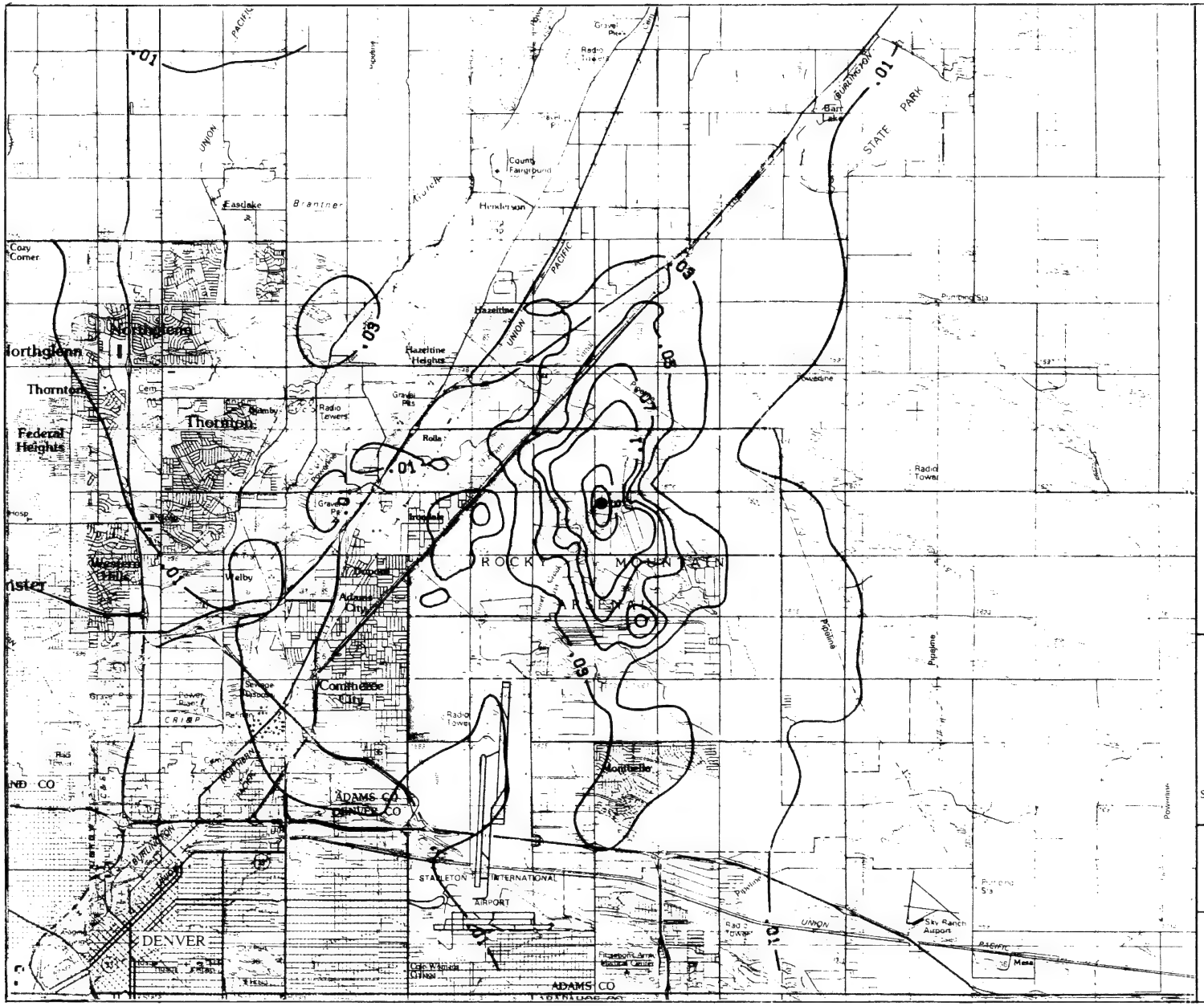
- Source emission parameters
  - Stack height
  - Stack gas velocity
  - Stack gas temperature
  - Pollutant emission rate
  - Building dimensions (for wake effects option)
- Mass particle size distribution.
- Particle density (by size).

Required meteorologic information is provided by the standard UNAMAP meteorologic preprocessor file. In addition, a value for the surface roughness coefficient (Z_o) must be supplied for each receptor. Model output includes the annual average pollutant concentration at each receptor, the total annual dry deposition at each receptor, and the average annual dry deposition velocity at each receptor. Figure 6-2 illustrates the dry deposition (5-year average dry deposition) in the study area based on the results of the WESDEP model.

6.3.2 Wet Deposition

The wet deposition process involves the removal of particles by precipitation. Currently, no widely accepted wet deposition models are available. Several studies have developed mechanisms for the removal of particles from the atmosphere during a rain storm. These studies assume that particle washout or scavenging is proportional to the mass of the plume exposed to the rain storm, the intensity and duration of the event, and the size distribution of the particles in the plume (Radke et al., 1980; Scire and Lurman, 1983).

The scavenging coefficients that have been developed in these studies are based on a very limited number of original studies and are generally related to removal of sulfate aerosols. For example, the work of Scire and Lurman (1983) is for sulfate and nitrate aerosols. Radke et al. (1980) included measurements in power plant, pulp and paper boilers, and volcanic plumes that have large concentrations of sulfate aerosols. Since these aerosols are



Legend:

.01 — ISOPLETH (gm/m^2)
FIVE YEAR AVERAGE
DRY DEPOSITION

NORTH

5000 0 5000 15000

SCALE IN FEET

1000 500 0 1000 2000 3000 5000

SCALE IN METERS

SOURCE: BASE MAP ADAPTED FROM USGS 30x60 MINUTE SERIES DENVER EAST AND DENVER WEST, COLORADO QUADS DATED 1981 AND 1983, RESPECTIVELY

SUBMERGED QUENCH INCINERATOR
BASIN F
ROCKY MOUNTAIN ARSENAL
COMMERCE CITY, ADAMS COUNTY
COLORADO

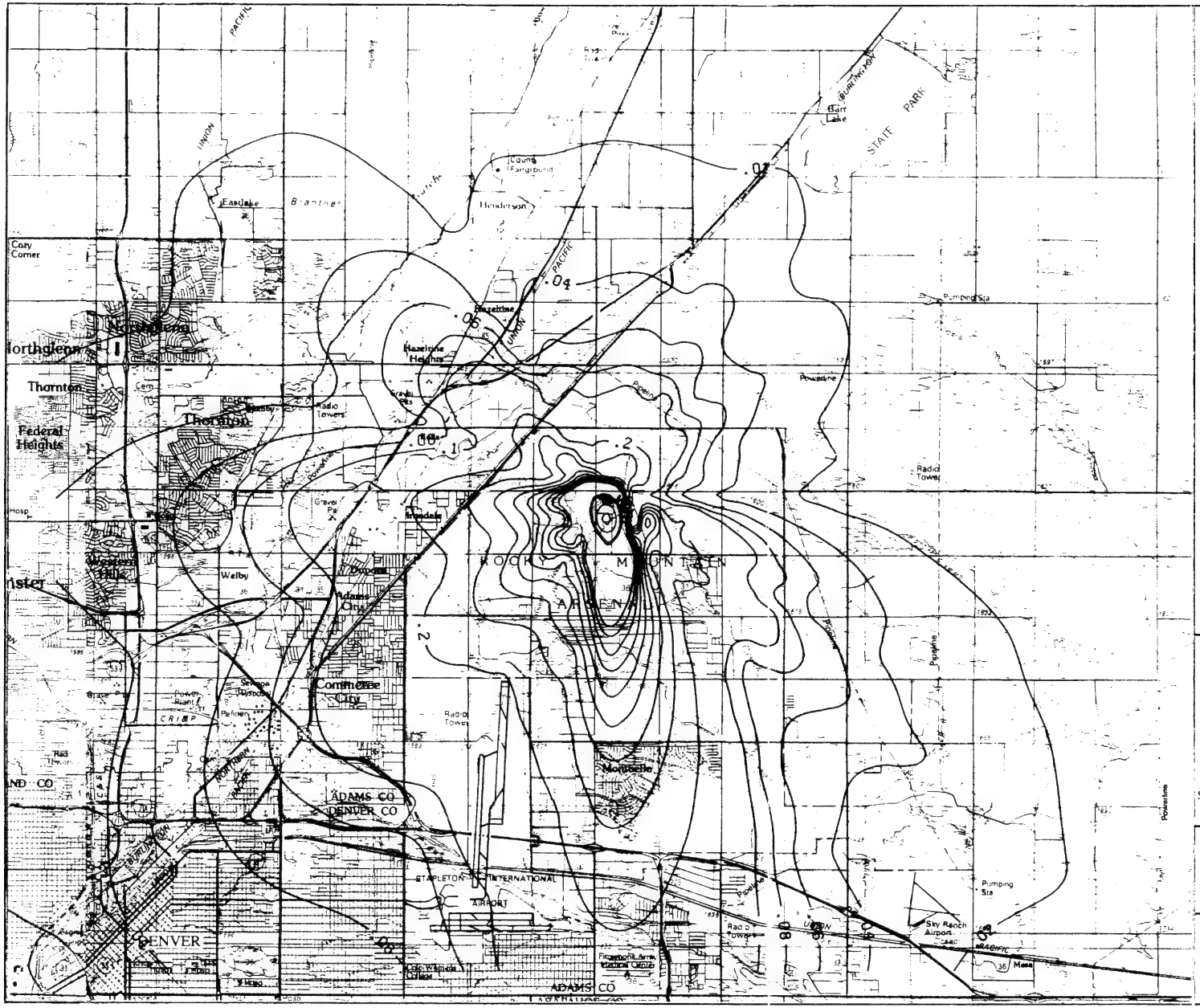
FIGURE 6-2
FIVE YEAR AVERAGE DRY DEPOSITION
ISOPLETH (gm/m^2)

hygroscopic (i.e., they have an affinity for absorbing water in the air), it is likely that scavenging coefficients based on these sources will be higher than for other less water-soluble species, such as the pollutants emitted by the SQI facility stack. Unfortunately, there are no quantifiable data available upon which to base a more reasonable scavenging coefficient. Therefore, the scavenging coefficients used in this study should be viewed as conservative and should provide an upper bound on the amount of wet deposition likely to occur in an area.

EPA (1986b) has developed an algorithm that uses scavenging coefficients to calculate wet deposition based on the work of Bowman et al. (1987) and Radke et al. (1980). The algorithm includes particle size and rainfall intensity-dependent washout coefficients to calculate wet deposition based on the mass of pollutants in a vertical column of air extending from the bottom to the top of the plume. WESTON has integrated this algorithm into the WESDEP model in order to conservatively calculate wet deposition resulting from rain storms.

To calculate wet deposition, the same information used for the dry deposition calculation is required (i.e., source-emission characteristics and hour-by-hour meteorology). In addition, rainfall intensity and rainfall type (e.g., thunderstorm, showers, steady precipitation) are also needed. This model has been modified to compute dry deposition only when no wet deposition, i.e., no rainfall, is occurring.

Figure 6-3 illustrates the predicted total wet deposition in the study area, and Figure 6-4 illustrates the total deposition (wet plus dry). A more detailed description of the overall deposition modeling analysis and relevant parameters are included in Appendix 6A (Revised Air Quality Modeling Protocol).


.02
.04
.06
.1
.2
.2
Legend:
.04
ISOPLETH (gm/m²)
FIVE YEAR AVERAGE
WET DEPOSITION
NORTH
5000 0 5000 15000
SCALE IN FEET
1000 500 0 1000 2000 3000 5000
SCALE IN METERS
SOURCE BASE MAP ADAPTED FROM USGS 30x60 MINUTE SERIES DENVER EAST AND DENVER WEST, COLORADO QUADS DATED 1981 AND 1983, RESPECTIVELY
SUBMERGED QUENCH INCINERATOR
BASIN F
ROCKY MOUNTAIN ARSENAL
COMMERCE CITY, ADAMS COUNTY
COLORADO
FIGURE 6-3
FIVE YEAR AVERAGE WET DEPOSITION
ISOPLETH (gm/m²)


.02
.04
.06
.08
.1
.2
.3
.9
Legend:
.1
ISOPLETH (gm/m²)
FIVE YEAR AVERAGE
TOTAL DEPOSITION
NORTH
5000 0 5000 15000
SCALE IN FEET
1000 500 0 1000 2000 3000 5000
SCALE IN METERS
SOURCE: BASE MAP ADAPTED FROM USGS 30x60 MINUTE SERIES, DENVER EAST AND DENVER WEST, COLORADO QUADS DATED 1981 AND 1983, RESPECTIVELY
SUBMERGED QUENCH INCINERATOR
BASIN F
ROCKY MOUNTAIN ARSENAL
COMMERCE CITY, ADAMS COUNTY
COLORADO
FIGURE 6-4
FIVE YEAR AVERAGE TOTAL DEPOSITION
ISOPLETH (gm/m²)

6.4 CHANGES IN THE MODEL SINCE 1991

The ambient air concentrations and soil deposition rates calculated for the trial burn emissions data employed the same stack parameters, operating conditions and meteorological information as originally used in the 1991 risk assessment. The use of the WESTDEP model was approved by EPA Region VIII in the protocol submitted 25 November 1990 and can be reviewed in Appendix 6A of the 1991 risk assessment (Volume II) (WESTON, 1991). However, the "as-built" stack diameter is slightly larger than originally assumed, and the exit temperature and velocity are slightly higher than estimated (Table 6-3). The effect of these changes of the main stack physical conditions on the ambient impact of the SQI was determined by using the U. S. EPA SCREEN model to predict the maximum 1-hour concentration for the "design" and "as-built" stack parameters. As shown in Table 6-4, the effect of the trial burn stack parameters on the ambient impact was a 15 percent decrease in the predicted maximum 1-hour pollutant concentration, and an increase of 7 percent of the distance to the maximum predicted concentration.

6.5 CONCLUSIONS

The SQI is located in an area that is defined as flat or simple terrain, based on EPA criteria. As a result, it was only necessary to conduct one type of modeling analysis to identify the worst-case predicted ground-level impact of the facility on ambient air quality. The simple terrain modeling was conducted using the EPA-approved model known as the Industrial Source Complex Short-Term (ISCST) air dispersion model, modified to allow for estimation of both wet and dry deposition rates. Differences between the "as-designed" and "as-built" parameters of the stack are likely to lead to an overestimate of about 15 percent in actual exposure levels.

SECTION 6

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Table 6-1

Air Quality Modeling Design Parameters and Particle Size Distribution for the SQI Facility

Particle Size Category	Particle Density (g/cm^3)	Mass Median Diameter (μm)	Surface Area Size Fraction (%)
20.0 - 35.0	2.0	28.2	0.0010
10.0 - 20.0	2.0	15.5	0.0010
7.0 - 10.0	2.0	8.59	0.0010
3.0 - 7.0	2.0	5.25	0.020
1.0 - 3.0	2.0	2.15	0.090
0.50 - 1.0	2.0	0.777	0.200
0.15 - 0.50	2.0	0.339	1.30
0.063 - 0.15	2.0	0.0835	1.83
0.013 - 0.063	2.0	0.0430	10.9
0.00 - 0.013	2.0	0.0085	85.7

Base Elevation	5,180 ft	1,578 m
Stack Height	100 ft	30.48 m
Inside Diameter	3.33 ft	1.02 m
Exit Velocity	48.4 fps	14.8 mps
Exit Temperature	178 °F	354 °K

Table 6-2

Receptor Grid Network

Ring Distances (meters)	Ring Increments (meters)	Number of Rings
300 - 500	200	1
500 - 800	300	1
800 - 1,000	200	1
1,000 - 3,000	500	4
3,000 - 6,000	1,000	3
6,000 - 10,000	2,000	2
10,000 - 25,000	5,000	3

Note: Receptors located along 10 degree radials from 10°- 360° for each of the distances shown above.

Discrete receptors were also located every 10 degrees from 10°-360° along the RMA property line.

Table 6-3

Design *vs.* Trial Burn Stack Characteristics of the SQI

Parameters	Design[a]	Trial Burn[b]
Base Elevation (m)	1,578	1,578
Stack Height (m)	30.48	30.48
Inside Diameter (m)	1.02	1.07
Exit Velocity (mps)	14.8	16.3
Exit Temperature (°K)	354	357

[a] Design stack parameters obtained from *Final Draft Human Health Risk Assessment*, July 1991, Table 6-1 (WESTON, 1991).

[b] As-built (trial burn) stack parameters obtained from trial burn test results, 12 June 1993.

Table 6-4

Comparison of Design *vs.* Trial Burn Predicted Maximum One-Hour Concentrations and Impact Distance From the SQI

SQI Condition	Maximum 1-hour Concentration ($\mu g/m^3$)	Distance 1-hour Maximum (m)
Design[a]	14.87	329
100% Basin F Liquid[b]	12.63	352

[a]*Final Draft Human Health Risk Assessment*, Section 6 (WESTON, 1991).
[b]As-built (trial burn) test results, 12 June 1993.

SECTION 7

DETERMINATION OF KEY PATHWAYS AND POLLUTANTS

7.1 INTRODUCTION

The exposure assessment serves as the cornerstone of the risk assessment process by providing an evaluation of the potential human exposure to the chemicals of concern. The first important step of the exposure assessment is to identify the exposure pathways that may impact off-site and on-site receptors. Human exposure to chemicals emitted by the SQI may occur through several potential environmental media (air, water, and soil) and by several routes of exposure (inhalation, ingestion, and dermal contact). However, gases and particulates emitted from the SQI are a complex mixture of elements and compounds, and not all of these emissions produce an adverse health effect through all exposure pathways. Therefore, a preliminary evaluation was performed to determine the pollutants of concern in each environmental pathway and to ensure that all pathways and pollutants that may potentially pose a risk to human health were addressed.

This section discusses in detail the process of pathway and pollutant selection. The subsequent evaluation focuses on those pathways and pollutants most critical to the risk assessment. It is important to note that the criteria used for screening potential pollutants and pathways are extremely conservative and eliminated pathways and pollutants are likely to have only a negligible effect on the risk results. Particular emphasis is placed on an evaluation of pollutants and pathways of specific concern for infants and children, who represent sensitive subgroups of the population.

Factors considered in this selection process included:

- Location of the SQI.
- Local land use.
- Local water use.

- Existing ambient background surface-water and soil pollutant concentrations.
- Transport modeling results.
- Relative toxicity of emitted pollutants.
- Persistence and mobility of pollutants in the environment.

7.2 THE PROCESS OF KEY PATHWAY AND POLLUTANT SELECTION

A screening evaluation of all possible pathways was conducted to determine the potential for population exposure. The framework for this process, illustrated in Figure 7-1, takes the form of a decision network designed to clearly identify the key exposure pathways and the pollutants likely to be associated with those pathways.

The first step is to evaluate the emission, dispersion, and deposition modeling data to determine the likelihood and extent of human exposure. The distribution profile of emitted pollutants in each of the environmental media is contrasted with local land and water use activities to determine the likelihood of exposure through a given pathway. The exposed population analysis identifies those pathways that are not anticipated to result in significant human exposure, and, accordingly, require no further analysis. The pathways associated with likely exposure are identified, and subsequently undergo a quantitative analysis to estimate the extent of pollutant transport through the environment and the magnitude of exposure to humans. This more detailed analysis of the magnitude of exposure is presented in Section 8 (Exposure Assessment).

The purpose of the pollutant selection process is to determine, for each identified pathway, those pollutants that may represent a potential hazard to the exposed population. Screening factors that were considered in this determination include:

- Comparison of predicted media concentrations of each pollutant with existing background levels.
- Comparison of media concentrations with established indices of toxicity, such as Ambient Water Quality Criteria (AWQC) for the Protection of Human Health.

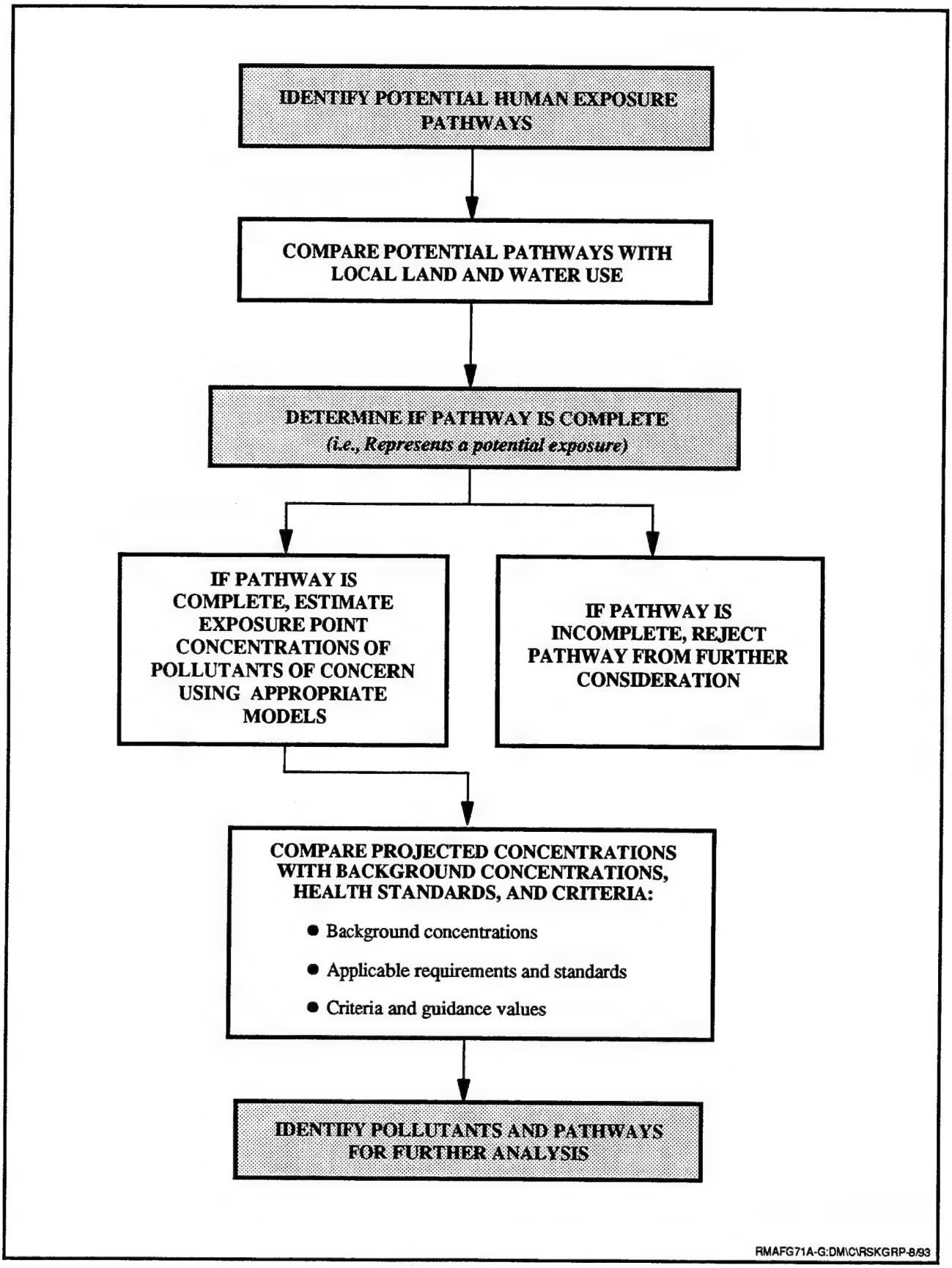

FIGURE 7-1 IDENTIFICATION AND CHARACTERIZATION OF HUMAN EXPOSURE PATHWAYS

- Toxicological evaluation in the absence of established toxicity criteria.
- Determination of persistence and mobility characteristics specific to each pathway (e.g., air, water, and soil).

The pathway and pollutant analysis is based on the assumption that pollutant transport and the resultant exposure to the population occur directly through air, and indirectly through soil and water. An assessment of the potential indirect exposure through the food supply and other ingestion pathways is conducted after the fate of the emitted material in air, soils, and water has been estimated. Using ambient concentration data developed for each of these media, a determination is made of the potential for the biological medium to serve as a pathway of human exposure. Such biological media may include garden fruits and vegetables, agricultural crops, agricultural livestock, and recreationally caught fish. A discussion of those routes of exposure via food consumption is presented for each of their respective pathways (e.g., soil-vegetable consumption, water-fish consumption). It should be noted that although lead is a potential contaminant of concern through the air and soil pathways, risk cannot be quantified because there are no approved toxicity criteria. Therefore, predicted soil and air concentrations were compared to appropriate standards or criteria (Table 10-24).

The subsections that follow present the rationale used for the determination of primary routes of exposure through air, soil, and water pathways.

7.3 AIR PATHWAY

7.3.1 Direct Inhalation

The inhalation of pollutants emitted to the atmosphere from the SQI represents a direct route of human exposure. The trace metal and organic pollutants in ambient air may exist either as vapor or as solids adsorbed onto stack gas particulate matter. The majority of trace metals emitted from the combustion process are generally adsorbed on particulates

in the gas stream, with the exception of the more volatile metals, such as mercury. Studies of the distribution of organic compounds between the solid (particulate) or vapor phase have yielded conflicting results. For example, some test data show a majority of organic compounds in the vapor phase, whereas other test data show a majority of organic compounds adsorbed onto the particulate matter (Czuczwa and Hites, 1985).

Given the equivocal nature of these studies, no judgment has been made in this risk assessment regarding the quantitative distribution of the pollutants between those adsorbed onto particulates or those in the vapor phase, with the exception of volatile organics, which are assumed to be in the vapor phase only. For the soil and water pathways, it is therefore assumed that the total mass of inorganics and semi-volatile organic pollutants emitted from the incinerator stack is adsorbed onto particulates for subsequent deposition on soil. It is likewise assumed for the inhalation pathway that the total mass of these pollutants emitted is available for inhalation. This assumption is extremely conservative and overestimates the chemical concentrations both breathed and ingested.

7.3.2 Selection of Pollutants

All pollutants identified in the trial burn emissions testing program (both carcinogens and noncarcinogens), including criteria gases and particulates, were evaluated for their potential adverse health effects through inhalation. In effect, the total human dose for all chemicals calculated in the exposure assessment for both direct (inhalation) and indirect (ingestion, dermal contact) routes is greater than would be received in reality. The pollutants selected for evaluation by the inhalation pathway are listed in Table 7-1.

7.4 SOIL PATHWAY

Both organic and inorganic pollutants adsorbed onto the particulate emissions from the SQI reach the soil through either wet or dry deposition. Once incorporated into the soil, the

pollutants are available for transport to human receptors through several pathways, including:

- Dermal absorption.
- Direct ingestion of soil.
- Ingestion of locally or home grown agricultural products.
- Consumption of meat and dairy products from locally raised cattle.

7.4.1 Potential Routes of Exposure

Based on local land use and population activity patterns in the vicinity of the RMA, the anticipated routes of exposure through the soil pathway are discussed in the subsections that follow.

7.4.1.1 Dermal Absorption Through Soil Contact

Exposure to pollutants incorporated into soils may result from direct contact with and subsequent absorption through the skin. The degree of exposure is largely dependent on the concentration of the pollutant in the soil, the absorption rate through the skin, the area of skin exposed, and the frequency of contact with the soil. Dermal exposure is expected to occur in both child and adult exposure scenarios. Home gardens and agricultural activities are common in some areas near the site and represent one of the principal dermal exposure routes for adults. Adult dermal exposure is evaluated in Subsection 8.2.3 of the exposure assessment. Children are expected to play outside (e.g., schools, back yards, etc.) and come in contact with soil. Dermal exposure of children is evaluated in Subsection 8.3.3.

7.4.1.2 Soil and Dust Ingestion

Adults and children may inadvertently ingest soil adhering to hands during work, gardening, or play. Consequently, soil and dust ingestion are considered potential routes of exposure for adults and children. These pathways are evaluated in Subsection 8.2.2.3.

7.4.1.3 Consumption of Vegetables from a Typical Home Garden

The exposure resulting from the consumption of vegetables from a typical home garden has been evaluated in the exposure assessment (Subsection 8.2.2.1) for the following reasons:

- The prevalence of home gardens within a 5-km radius of the site.
- The potential for vegetables to accumulate certain pollutants from the soil or for the pollutants to adhere to plant surfaces.

7.4.1.4 Consumption of Milk

Dairy cattle are raised in the vicinity of the SQI facility. The potential exists for bioconcentration of some pollutants in the milk of dairy livestock through contaminated feed ingestion, and local residents and farmers are anticipated to consume some home- or locally-produced milk. Therefore, exposure resulting from the consumption of cow's milk is evaluated in Subsection 8.2.2.2.

7.4.1.5 Consumption of Beef Products

In addition to dairy cattle, livestock may also be raised for beef consumption. Beef production is regarded as a potential mechanism of indirect human exposure to pollutants emitted from hazardous waste incinerators and resource recovery facilities (EPA, 1990a). A quantitative exposure assessment is presented for this pathway in Subsection 8.2.2.2.

7.4.2 Selection of Pollutants for Soil Pathway

To select pollutants of concern in the soil pathway, conservative pollutant soil concentrations calculated from SQI stack emissions data were compared to existing background soils data. This screening is done only for inorganics. Organic background data were not available.

The following equation was used to predict conservative soil concentrations of the inorganics:

$$CS = \frac{DR * AT * CF}{BD * D}$$

Where:

CS = Total pollutant concentration in soil due to deposition from facility (mg/kg).

DR = Pollutant total deposition rate ($g/m^2/yr$).

AT = Accumulation time (2-year lifetime of incinerator unit).

BD = Bulk density of soil (1,425 kg/m^3).

D = Mixing depth (0.01 m) - the depth of the soil in which the element is retained and presumed to be equally distributed.

CF = Conversion factor (1,000 mg/g).

The soil bulk density was based on an average bulk density value for various soil types that occur in the vicinity of RMA (Price, 1990).

In estimating soil concentrations for this initial screening analysis, several conservative assumptions were made:

- Soil concentrations were calculated using either the 95 percent upper confidence limit (95 percent UCL) on the arithmetic mean, or the maximum, whichever was lower. This approach is likely to result in an overestimation of the probable soil concentrations.
- Soil concentrations were calculated at the location of maximum total (wet and dry) deposition. This represents the maximum possible soil pollutant concentrations to which a potential human receptor could be exposed.

- Pollutants were assumed to be distributed equally throughout the soil to a depth of only 1 centimeter (0.01 m). This approach is likely to overestimate soil concentrations by at least one order of magnitude since a more realistic mixing depth is 10 to 20 cm (0.1-0.2m).

Soil concentrations of inorganic chemicals based on 95 percent UCL or maximum emission rates are presented in Table 7-2. Appendix 8A presents the derivation of soil concentrations for both organics and inorganics selected for detailed evaluation in the exposure assessment (Section 8). To determine whether emissions from the SQI facility would elevate the concentrations of inorganics in the soil, the conservatively predicted levels were compared with local average soil background concentrations measured at an off-site location near Brighton (PMRMA, 1991). For those metals for which data were not available at the Brighton location, background soils data measured at the Rocky Flats facility were used (WESTON, 1989). Inorganic pollutants with predicted soil concentrations of less than 1 percent of the background levels (i.e., those with a predicted soil-to-background ratio of less than 0.01) were excluded as pollutants of concern for the soil pathway. Based on this criterion, the following metals were eliminated from all exposure routes of concern in the soil:

- Aluminum
- Barium
- Boron
- Calcium
- Chromium III
- Chromium VI
- Iron
- Manganese
- Molybdenum
- Nickel
- Silver
- Tin
- Titanium
- Vanadium
- Zinc

Metals classified as carcinogens by the oral route (arsenic and lead) were included even though their predicted soil level met the criterion for exclusion. Metals known to be carcinogenic only by the inhalation route (cadmium, chromium VI, and nickel) were screened from the soil pathway (but were included in the inhalation pathway) on the basis of the background criteria.

All volatile organic compounds (VOCs) were excluded from the soil pathway based on the following reasoning:

- VOCs are likely to be emitted as vapors and do not tend to adsorb onto particulates.
- VOCs are not likely to be deposited in soils following their emission.
- VOCs are not likely to be persistent in soils, if deposited.

For purposes of this screening procedure, a VOC is defined as any chemical (carcinogen or noncarcinogen) with a vapor pressure greater than 1E+02 mm Hg and/or Henry's Law constants greater than 1E-03 atm-m^3/mol (Lyman et al., 1982). The vapor pressure criterion was derived from inspection of the range of vapor pressures of chemicals that EPA classifies as volatiles (EPA, 1986a).

All other organic compounds detected in stack emissions list were included for evaluation in the final soil pathway. Critera pollutants and acid gases were excluded on the basis of their physical state (gas) and were evaluated only in the inhalation pathway. The final list of contaminants that were evaluated for the soil pathway are presented in Table 7-3.

7.5 SURFACE WATER PATHWAY

There are no water bodies designated for drinking water use within a 10-km radius of the SQI; hence, this pathway was not considered in the risk assessment. Several surface water bodies were identified near the site that provide a potential for indirect exposure to contaminants through the ingestion of fish.

Four small water bodies designated for recreational fishing are located approximately 8 km west of the SQI and were within the predicted deposition area.

- Clear Creek Pond.
- Engineers Lake.
- Rotella Park Pond.
- Grandview Ponds 1-4.

Based on the air dispersion and surface deposition isopleths (Section 6), Engineers Lake was determined to be the water body with the highest potential for impact. Data for surface area and depth of Engineers Lake were provided by the Department of Natural Resources (DNR), Department of Wildlife and were confirmed by the Adams County Park Service. Some data required for the surface water modeling of contaminant loading, such as flow rates and average suspended solids concentrations, were not available for Engineers Lake, and assumptions were therefore made for these parameters (see Appendix 7A). Appendix 3A contains published data on specific locations and fish populations for Engineers Lake and the other three recreational fishing areas that were evaluated.

Much of the surface water drainage from RMA eventually drains into the South Platte River. The South Platte River was excluded as a potential human exposure pathway through fish consumption for the following reasons:

- Any contaminants entering the South Platte River as runoff (resulting from on-site deposition from the incinerator) will likely be highly diluted on a continual basis due to the river's low retention time and high flow rate. Therefore, bioaccumulation potential in game fish is anticipated to be relatively low compared with ponds or lakes where retention times are much longer and the volume of surface water available for contaminant loading is much smaller.

- Deposition into the South Platte River was not significant relative to deposition predicted for the previously discussed recreational fishing areas (i.e., Engineers Lake).

7.5.1 Selection of Pollutants for the Surface Water Pathway

Contaminants for the surface water pathways were initially screened using a modification of the conservative Tier 1 analysis (EPA, 1986b). The contaminant water concentrations

calculated with the Tier 1 method are based on the assumption that all contaminants, other than VOCs, emitted from the facility in a 1-year period are directly deposited into the lake. The Tier 1 screening model normally assumes that 100 percent of the emitted pollutant mass is concentrated into a water column with a volume equivalent to one square meter multiplied by its depth (in meters) to compensate for the large dilution factor usually associated with the high flow rates and short retention times of rivers and streams (for which the Tier 1 model is designed). Since Engineers Lake was assumed to have a relatively low hydraulic residence time (0.5 year) (i.e., the lake would be flushed twice a year), it would be too conservative to use the water column volume to calculate the water concentrations of contaminants. Therefore, the Tier 1 model was modified to assume that pollutants emitted in one year are distributed throughout the lake's volume for the screening. In addition, the 95 percent UCL or maximum emission rates were used, and no degradation or dilution was assumed. All VOCs were excluded from this analysis and from the detailed surface water pathway evaluation using the same criteria as employed for soils (Subsection 7.4.2). The results of this modified Tier 1 analysis are still very conservative, thus only chemicals contributing insignificantly to risk will be eliminated. Refer to Appendix 7A for a detailed description of the calculations.

The surface water concentrations for each contaminant predicted from the Tier 1 analysis and the respective Ambient Water Quality Criteria (AWQC) for fish ingestion (EPA, 1986c) are presented in Table 7-4. Contaminants were selected for analysis in the surface water pathway if the predicted surface water concentrations for a given chemical exceeded 10 percent of its respective health-based AWQC, or if the contaminant was carcinogenic by the oral exposure route. All contaminants evaluated in the screening process were less than 10 percent of their health-based AWQC (Table 7-4) and were therefore excluded from further analysis. Based on the Tier 1 screening, the list of pollutants selected for the surface water pathway appears in Table 7-5.

The Tier 1 surface water concentrations are overly conservative and are intended only for screening purposes. The Tier 2 method (Appendix 7A) is used to further evaluate surface

water concentrations for the selected surface water pathway contaminants presented in Section 8. It takes into account deposition and dilution based on lake volume and outflow.

7.6 CONSUMPTION OF BREAST MILK

An important pathway for evaluation is the consumption of breast milk by infants nursing from mothers exposed directly or indirectly to facility emissions. Chemicals that bioaccumulate in fat may achieve measurable levels in breast milk. Such compounds are organic chemicals with high lipid solubility and persistence in body tissues (i.e., long whole body half-lives). The limiting factor in evaluating these pollutants in this pathway is the lack of available half-life and tissue distribution data necessary to determine breast milk concentrations (refer to Appendix 8G for the equations and assumptions).

In order to be conservative, all organic compounds (regardless of fat solubility and degradation rate) were included in the evaluation of the breast milk consumption pathway. Appendix 8G presents the detailed calculations. Inorganics were excluded from this evaluation due to the insufficiency of data for estimating breast milk concentrations.

7.7 SUMMARY OF CRITICAL PATHWAYS AND ASSOCIATED POLLUTANTS OF CONCERN

The following list presents the routes of exposure believed to be of possible significance for each environmental medium selected on the basis of the pollutant pathways analysis:

- Direct inhalation of pollutant emissions.
- Ingestion of soil/house dust.
- Dermal absorption through soil contact.
- Consumption of vegetables from home gardens.
- Consumption of cow's milk.
- Consumption of beef products.
- Consumption of fish.
- Consumption of breast milk by nursing infants.

These pathways and their relationships to each other are presented in Figure 7-2.

Table 7-6 lists the pollutants of concern selected for the quantitative exposure assessment and risk characterization for each of these pathways.

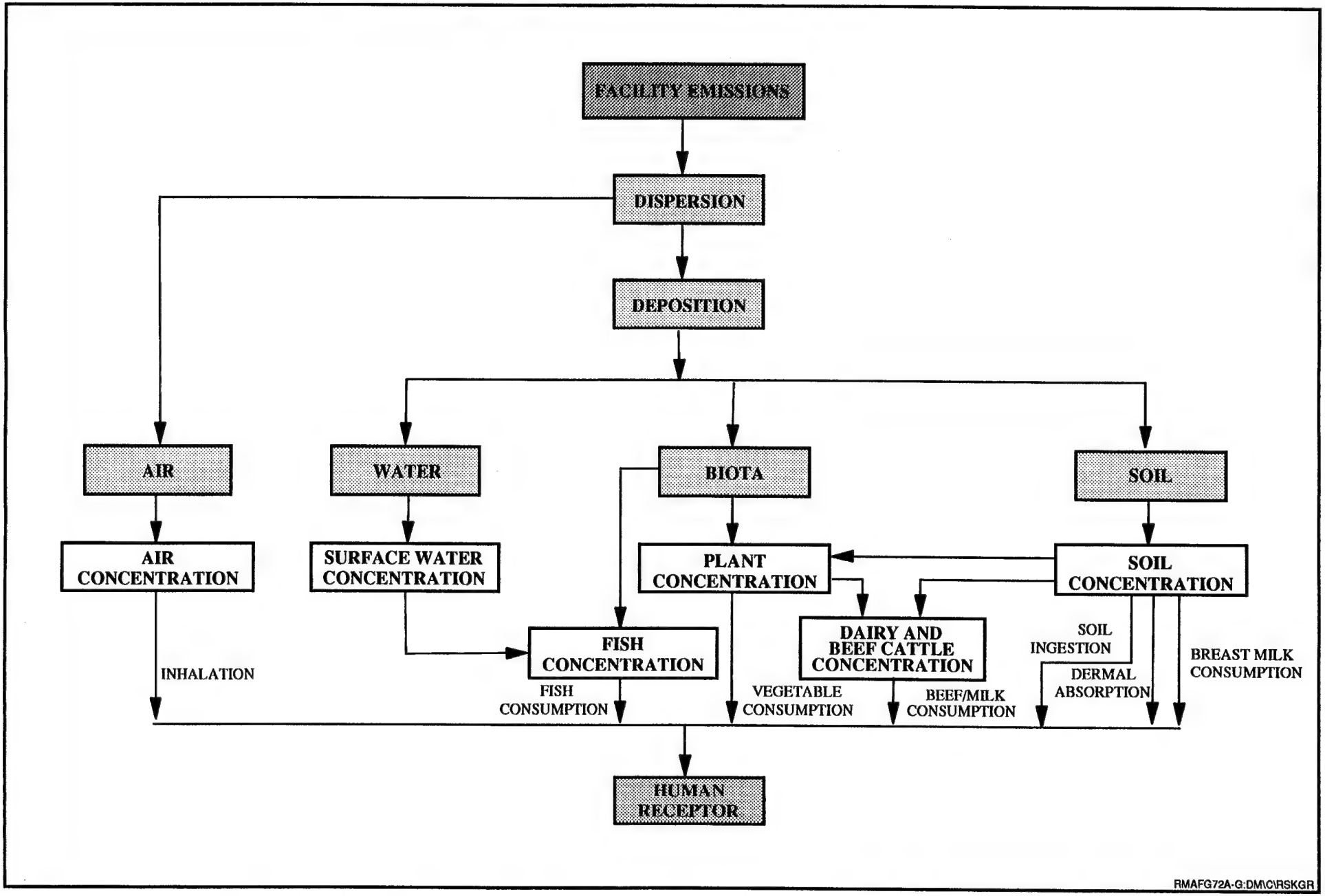

FIGURE 7-2 ENVIRONMENTAL PATHWAYS AND ROUTES OF EXPOSURE

SECTION 7

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Table 7-1

List of Pollutants Selected for Inhalation Pathway Evaluation

Organics	Inorganics
Benzene	Aluminum
Benzoic Acid	Antimony
Bis(2-ethylhexyl)phthalate	Arsenic
Bromodichloromethane	Barium
Butylbenzylphthalate	Boron
Carbon Tetrachloride	Cadmium
Chlorobenzene	Calcium
Chloroform	Chromium (III)
Dibromochloromethane	Chromium (VI)
Di-n-butylphthalate	Copper
Diethylphthalate	Iron
Dimethylphthalate	Lead
Dioxins/Furans (EPA TEFs)	Manganese
Heptachlor Epoxide	Mercury
Methyl Chloride	Molybdenum
Methylene Chloride	Nickel
Styrene	Silver
Toluene	Tin
Xylene	Titanium
	Vanadium
	Zinc
Criteria Pollutants/Acid Gases	
Carbon Monoxide	
Hydrogen Chloride	
Hydrogen Fluoride	
Nitrogen Oxides (NO_x)	
Particulate Matter	
Sulfur Dioxide	
Sulfuric Acid Mist	

Table 7-2

Comparison of Predicted Inorganic Soil Concentrations Due to Submerged Quench Incinerator Emissions with Existing Background Levels

Pollutant	2-Year Soil Concentration[a] (1 cm) Due to Incinerator Emissions (mg/kg)	Mean Background Soil Concentration (mg/kg)	Soil Concentration:[b] Mean Background Ratio
Inorganics			
Aluminum	0.007	15,358.0[c]	0.00
Antimony[d]	0.000	ND[c]	NA
Arsenic[d,e]	0.001	ND[f]	NA
Barium	0.003	131.0[c]	0.00
Boron	0.014	29.0[c]	0.00
Cadmium[d]	0.000	ND[f]	NA
Calcium	0.073	6,379.0[c]	0.00
Chromium (III)	0.000	14.0[f]	0.00
Chromium (VI)	0.000	1.4[g]	0.00
Copper[d]	0.150	8.0[f]	0.02
Iron	0.003	16,424.0[c]	0.00
Lead[d,e]	0.002	15.3[f]	0.00
Manganese	0.001	180.0[c]	0.00
Mercury[d]	0.005	ND[f]	NA
Molybdenum	0.001	14.0[c]	0.00
Nickel	0.001	20.0[c]	0.00
Silver	0.000	8.3[c]	0.00
Tin	0.001	109.0[c]	0.00
Titanium	0.001	2,600.0[c]	0.00
Vanadium	0.001	39.0[c]	0.00
Zinc	0.038	42.2[f]	0.00

[a]Values shown as 0.000 are <0.001 because of rounding off to the nearest one-thousandth.
[b]Values shown as 0.00 were <0.01 because of rounding off to nearest one-hundredth.
[c]Source of background value - WESTON Draft Background Geographical Characterization Report, Rocky Flats Plant, Golden, Colorado. Prepared by Roy F. Weston, Inc., December 1989.
[d]Selected as a contaminant of concern for soil pathway analysis. However, at EPA's request, lead was not evaluated for potential noncarcinogenic and carcinogenic risks. Rather for lead, estimated soil concentrations were compared to clean-up criteria, and air concentrations to air quality standards.
[e]Carcinogen by oral route of administration (EPA, 1990b).
[f]Source of background value - Personal communication with Katherine Cain (PMRMA), 1991. This data was collected under the off-post RI and is in the RMA database.
[g]Assumed 10% of chromium (total).
ND = Not detected.
NA = Not able to be calculated.

Table 7-3

List of Pollutants Selected for Soil Pathway Evaluation

Organics	Inorganics
Benzoic Acid	Antimony
Bis(2-ethylhexyl)phthalate	Arsenic
Butylbenzylphthalate	Cadmium
Dibromochloromethene	Copper
Di-n-butylphthalate	Lead
Diethylphthalate	Mercury
Dimethylphthalate	
Dioxins/Furans (EPA TEFs)	
Heptachlor Epoxide	

Table 7-4

Comparison of Predicted Surface Water Contaminant Concentrations in Engineers Lake with EPA AWQC for Protection of Human Health (Fish Consumption)

Pollutant	Predicted Surface-Water Concentration (mg/L)	EPA AWQC[a] (mg/L)	Surface Water Concentration as Percent of EPA AWQC
Organics			
Diethylphthalate	5.56E-09	1.80E+03	3.09E-10
Dimethylphthalate	2.11E-09	2.90E+03	7.28E-11
Di-n-butylphthalate	6.29E-09	1.54E+02	4.08E-09
Inorganics			
Antimony	4.42E-09	4.50E+01	9.82E-09
Barium	3.18E-08	1.00E+00	3.18E-06
Cadmium	8.14E-10	1.00E-02	8.14E-06
Chromium (III)	1.53E-09	3.43E+03	4.46E-11
Chromium (VI)	3.35E-10	5.00E-02	6.70E-07
Iron	3.63E-08	3.00E-01	1.21E-05
Manganese	7.19E-089	1.00E-01	7.19E-06
Mercury	5.69E-08	1.46E-04	3.90E-02
Nickel	6.36E-09	1.00E-01	6.36E-10
Silver	1.58E-09	5.00E-02	3.16E-06

[a]EPA. 1986c. Quality Criteria for Water. Office of Water Regulations and Standards, Washington, DC. EPA440/5-86-001. Values shown are for fish consumption.

Table 7-5

List of Pollutants Selected for Surface Water Pathway Evaluation

Organics	Inorganics
Benzoic Acid	Aluminum
Bis(2-ethylhexyl)phthalate	Arsenic
Butylbenzylphthalate	Boron
Dibromochloromethane	Calcium
Dioxins/Furans (EPA TEFS)	Copper
Heptachlor Epoxide	Molybdenum
	Tin
	Titanium
	Vanadium
	Zinc

Table 7-6

Final List of Pollutants and Respective Exposure Pathways to Be Evaluated

Pollutants	Inhalation	Vegetable Consumption	Milk Consumption	Beef Consumption	Soil/Dust Ingestion	Fish Consumption	Dermal Absorption	Breast Milk Ingestion
Organics								
Benzene	X							X
Benzoic Acid	X	X	X	X	X	X	X	X
Bis(2-ethylhexyl)phthalate	X	X	X	X	X	X	X	X
Bromodichloromethane	X							X
Butylbenzylphthalate	X	X	X	X	X	X	X	X
Carbon Tetrachloride	X							X
Chlorobenzene	X							X
Chloroform	X							X
Dibromochloromethane	X	X	X	X	X	X	X	X
Di-n-butylphthalate	X	X	X	X	X		X	X
Diethylphthalate	X	X	X	X	X		X	X
Dimethylphthalate	X	X	X	X	X		X	X
Dioxins/Furans	X	X	X	X	X	X	X	X
Heptachlor epoxide	X	X	X	X	X	X	X	X
Methyl Chloride	X							X
Methylene Chloride	X							X
Styrene	X							X

Table 7-6
Final List of Pollutants and Respective Exposure Pathways to Be Evaluated
(continued)

Pollutants	Inhalation	Vegetable Consumption	Milk Consumption	Beef Consumption	Soil/Dust Ingestion	Fish Consumption	Dermal Absorption	Breast Milk Ingestion
Toluene	X							X
Xylene	X							X
Inorganics								
Aluminum	X							
Antimony	X	X	X	X	X		X	
Arsenic	X	X	X	X	X	X	X	
Barium	X							
Boron	X							
Cadmium	X	X	X	X	X		X	
Calcium	X							
Chromium (III)	X							
Chromium (VI)	X							
Copper	X	X	X	X	X	X	X	
Iron	X							
Lead	X							
Manganese	X							
Mercury	X	X	X	X	X		X	
Molybdenum	X							
Nickel	X							

Table 7-6
Final List of Pollutants and Respective Exposure Pathways to Be Evaluated
(continued)

Pollutants	Inhalation	Vegetable Consumption	Milk Consumption	Beef Consumption	Soil/Dust Ingestion	Fish Consumption	Dermal Absorption	Breast Milk Ingestion
Silver	X							
Tin	X							
Titanium	X							
Vanadium	X					X		
Zinc	X					X		
Criteria Pollutants/ Acid Gases								
Carbon Monoxide	X							
Hydrogen Chloride	X							
Hydrogen Fluoride	X							
Nitrogen Oxide	X							
Particulate Matter	X							
Sulfur Dioxide	X							

X = Pollutant is of potential concern through this exposure route or pathway.

SECTION 8

EXPOSURE ASSESSMENT

8.1 INTRODUCTION

The goal of this section is to predict the potential exposure point concentrations and the daily intakes for all of the identified pathways and pollutants. This section incorporates information from each of the preceding sections with site-specific information such as meteorological conditions, land use patterns, agricultural practices, etc., in order to predict the pollutant levels to which on-site and off-site populations might be exposed. Daily intakes of pollutants were estimated for each of the individuals and were used in the estimation of risk, based on the toxicity values presented in Section 9.

Dispersion and deposition modeling, presented in Section 6, identified how pollutants are expected to be distributed in the area surrounding the SQI. Dispersion modeling identified the ambient air concentrations of the pollutants, and deposition modeling identified the pollutant deposition rates under both dry and wet deposition conditions. This information was integrated with information concerning land uses surrounding the SQI to select potential human receptors for use in the exposure assessment.

8.1.1 Characterization of Exposure Scenarios

Numerous potential exposure scenarios are possible in the study area surrounding the SQI at RMA. The objective of this assessment is to calculate the potential risk to a reasonable maximally exposed individual (RMEI). "Reasonable maximum exposure" is defined by the EPA as "the highest exposure that is reasonably expected to occur at a site." Calculation of RME doses employs upperbound (about the 95th percentile) of exposure parameters such as intake rate and exposure duration, along with the 95 percent upper confidence limit (UCL) of the media concentrations (EPA, 1989a). As described in Section 5, the 95 percent

UCLs of the arithmetic mean emission rates were based on the results of three sampling events of the SQI stack emissions conducted during the trial burn (10, 11 and 12 June 1993). The 95 percent UCL emission rate, or the maximum detected value if the 95 percent UCL exceeded the maximum, was used to calculate doses and risks for the RMEI.

An additional factor that contributes to the RMEI is the location of maximum pollutant deposition. Because the results of the modeling effort indicate varying patterns of wet deposition, dry deposition, and ambient air concentrations, both within and outside the arsenal boundaries, it is difficult to define a single location or individual that represents the reasonable maximally exposed person. Therefore, to meet the requirements of the *Final Decision Document* (Woodward-Clyde, 1990a), four exposure scenarios were evaluated in the risk assessment, as follows:

- Resident-A
  A hypothetical individual currently living within the off-site residential area where inhalation and dry deposition will be maximal (i.e., just north of the fenceline).

- Resident-B
  A hypothetical individual currently living within the off-site residential area where total deposition (dry plus wet) is maximal (i.e., just south of the property fenceline).

- Farmer
  A hypothetical individual currently living on a local cattle farm where total deposition is highest for that land use (i.e., just northwest of site).

- On-site Worker
  A maintenance worker on-site exposed to area-weighted air and soil concentrations of pollutants as determined from the modeling results.

The scenarios presented above represent current land use conditions. No future land use conditions were evaluated since pathways of exposure and areas of maximum effect of emissions would not be different from any of the present use conditions assessed.

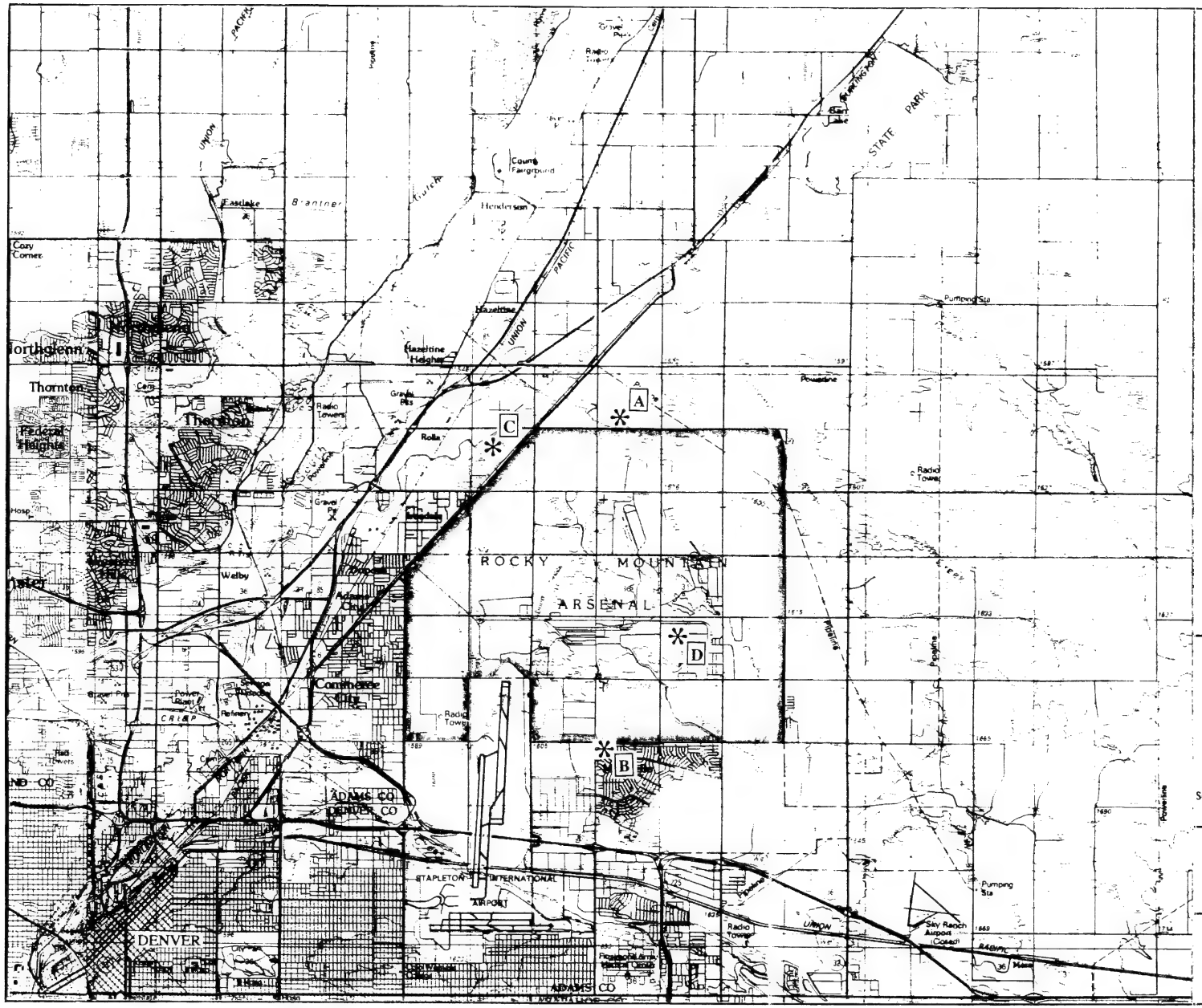
The respective locations of these four RMEIs are indicated on the site diagram in Figure 8-1. The modeling approach and the isopleths that depict patterns of dry/wet deposition and ambient air concentrations are presented in more detail in Section 6. Chart 8-1 summarizes the modeling factors (i.e., deposition and ambient air factors) that were chosen for evaluation in each of the four scenarios. Modeling factors are presented for the Resident-A, the Resident-B, the Farmer, and the Worker locations (i.e., area-weighted values for RMA). Modeling factors for Engineers Lake are also included in the chart since fishing is evaluated in the Resident-A, Resident-B, and Farmer scenarios. The following text describes in detail the exposure routes and general assumptions for each scenario.

Resident-A Scenario — Resident-A is assumed to be living in a residential area where off-site dry deposition and ambient air concentrations are maximal. This area falls outside the arsenal boundaries (off-site) because individuals are not permitted to live on the grounds of the arsenal (U.S. Army, 1990a). The maximum off-site dry deposition and air concentration occur at the same location, directly north of the arsenal (i.e., bearing 010° and 2,000 meters from the SQI). The site-specific contribution of wet deposition at this location was also included.

Resident-A is assumed to be exposed to all pathways of exposure listed for the air (Subsection 7.3), soil (Subsection 7.4), and surface water (Subsection 7.5) pathways. The air pathway represents the route of exposure for pollutant inhalation. The soil pathway includes the following routes of exposure:

- Soil/dust ingestion.
- Dermal absorption.
- Vegetable consumption.
- Milk and beef consumption.

The surface water pathway includes the fish ingestion route of exposure. The milk and beef that are consumed are assumed to be obtained from a local farm, which is the same farm evaluated under the Farmer scenario.



LEGEND:

* POTENTIAL RECEPTOR LOCATIONS

A - AREA OF MAXIMUM DRY DEPOSITION AND MAXIMUM GROUNDLEVEL AMBIENT AIR CONCENTRATION (RESIDENT A)

B - AREA OF MAXIMUM TOTAL DEPOSITION (RESIDENT B)

C - AREA OF MAXIMUM TOTAL DEPOSITION FOR LOCAL CATTLE FARM (FARMER)

D - ON SITE MAINTENANCE WORKER EXPOSED TO AIR A WEIGHTED TOTAL DEPOSITION AND GROUNDLEVEL AMBIENT AIR CONCENTRATIONS

NORTH

5000 0 5000 15000

SCALE IN FEET

1000 500 0 1000 2000 3000 5000

SCALE IN METERS

SOURCE: BASE MAP ADAPTED FROM USGS 30x60 MINUTE SERIES, DENVER EAST AND DENVER WEST, COLORADO QUADS DATED 1981 AND 1983, RESPECTIVELY

SUBMERGED QUENCH INCINERATOR BASIN F ROCKY MOUNTAIN ARSENAL COMMERCE CITY, ADAMS COUNTY COLORADO

FIGURE 8-1
GENERAL LOCATIONS OF REASONABLE MAXIMALLY-EXPOSED INDIVIDUALS BASED UPON AMBIENT AIR AND DEPOSITION MODELING

Chart 8-1

Modeling Factors Used for the Four RMEI Scenarios and Engineers Lake

	Dry Deposition (g/m^2/year per g/sec)	Total Deposition (g/m^2/year per g/sec)	Air Concentration ($\mu g/m^3$ per g/sec)
Resident A[a]	1.47E-03	3.09E-03	3.51E-01
Resident B[b]	2.55E-04	5.02E-03	6.96E-02
Farmer[c]	5.05E-04	3.00E-03	1.22E-01
On-Site Worker[d]	4.83E-04	4.46E-03	1.05E-01
Engineers Lake[e]	NA	9.00E-04	NA

[a] Represents area of peak dry deposition and area of peak ambient air concentration. Also includes wet deposition at that location.

[b] Represents area of peak wet deposition and includes dry deposition and ambient air concentrations at that location.

[c] Represents area of peak dry and total deposition, and peak ambient air concentration for the farming land use.

[d] Represents area-weighted values for Rocky Mountain Arsenal.

[e] Represents area-weighted values for Engineers Lake.

NA = Not Applicable.

Mother's milk ingestion and inhalation are the only pathways evaluated for infants (all resident and farmer scenarios).

Resident-B Scenario — Resident-B is assumed to be living in a residential area where off-site wet (and total) deposition is maximal. The Resident-B location falls directly south of the arsenal (bearing 180° and 6,000 meters from the SQI). Resident-B is assumed to be exposed through the same pathways of exposure as Resident-A.

Farmer Scenario — For the Farmer scenario, it was assumed that a cattle farm is located where off-site deposition (wet and dry) and air concentration are highest for that land use. Based on discussions with local agricultural agencies, it seems highly unlikely that new farms would be started in the RMA vicinity, since the area around RMA is becoming increasingly developed. Thus, the farmer location, chosen based on areas where cows are presently observed grazing, is located off-site (bearing 300° and 2,500 meters from the SQI). It was assumed that the individual at this location not only raises beef and dairy cattle, but also grows cattle feed and vegetables. The pathways of exposure evaluated under the Farmer scenario are the same as those being evaluated for the Resident-A and Resident-B scenarios.

Worker Scenario — Since the highest air concentration of pollutants as well as maximum deposition and consequent soil concentrations were predicted to occur on the arsenal site proper, a scenario that evaluates a worker at the arsenal was developed. Maximal exposure would occur to those workers who spend the greatest amount of time outdoors. Maintenance workers on the road and the grounds crew spend 90 percent of a working year outside, and therefore, they represent the workers at the arsenal who have the highest potential for exposure. Their work activities include repairing and grading roads, building or fixing culverts and drainage ditches, building or tearing down fences, snow removal, etc. They have complete access to the entire arsenal (1,700 acres), and could be working in any area of the arsenal at any given time (U.S. Army, 1990b). Thus, area-

weighted total deposition rates and air concentrations for the entire arsenal were used in estimating risk to the worker.

The routes of exposure evaluated under the Worker scenario include inhalation, soil/dust ingestion, and dermal absorption from soil. These are the only routes through which exposure is expected to occur to the worker.

8.1.2 General Approach

The following subsections evaluate the potential exposure to pollutants through each of the exposure routes discussed above and are summarized in Table 8-1. The estimated exposure point concentrations were calculated using the measured emission rates for each of the pollutants (see Section 5). Pollutant intakes expressed in milligrams of pollutant per kilogram of body weight per day (mg/kg-day) were calculated for an adult (Subsection 8.2), a child age 1 to 6 years, (Subsection 8.3) and an infant age 0 to 1 years (Subsection 8.3). Because of their behavioral patterns (e.g., frequent hand-to-mouth contact, frequent outdoor play) and their small body size, small children often tend to have a greater intake of pollutants per unit of body weight than an average adult and, therefore, might be at a higher risk for some effects. Similarly, breast feeding infants, because of their small body size, may present a risk because of the concentration of pollutants in mother's milk.

The calculation of exposure doses is a complex process and involves numerous variables that must be estimated. In calculating exposure doses, exposure factors consistent with the following documents were developed:

- Ebasco Services, Inc. 1990. *Final Human Health Exposure Assessment for the Rocky Mountain Arsenal. Volume IV. Preliminary Pollutant Limit (PPLV) Methodology*. Version 4.1. September, 1990. Contract No. DAAA15-88-0024. (Final).

- ESE (Environmental Science & Engineering, Inc.), Harding Lawson Associates, and Applied Environmental, Inc. 1989. *Technical Support for Rocky Mountain Arsenal. Offpost Operable Unit Endangerment Assessment/Feasibility Study with Applicable and Appropriate Requirements. Volume I.* March 1989. Contract No. DAAA15-88-D-0021. (Draft Final).

- Woodward-Clyde Consultants. 1990b. *Draft Public Health Risk Assessment Report. Submerged Quench Incinerator, Task IRA-2, Basin F Liquids Treatment Design.* Version 2.1. January 1990. Contract No. DAAA15-88-D-0022/0001. (Final).

When exposure factors were available in these documents, they were used. If appropriate exposure factors were not available, or there were inconsistencies between available factors and the identified exposure scenarios, then standard EPA references or other relevant references were used for their selection. In some cases, variables specific to the RMA area were obtained from local agencies (e.g., types of livestock, types of forage, crop yield, growing time for vegetables, etc.). Table 8-2 summarizes the exposure assumptions for all routes of exposure. Tables that present the predicted intakes of pollutants through the applicable exposure routes for adults, children, and infants are presented at the end of Section 8.

The soil concentrations used in the estimation of pollutant intakes through soil-mediated exposure routes were based on pollutant deposition calculated for a 2-year facility lifetime. Two soil concentrations were calculated for pollutants of concern through soil-related pathways, one representing the maximum soil concentration (i.e., the concentration at the end of the second year), the other representing the average soil concentration over 70 years (an average lifetime). They are described in Appendix 8A. The average soil concentrations over the 70-year exposure period were used in calculating carcinogenic risk through all soil-mediated pathways based on exposure as a child and as an adult since the calculation of carcinogenic risk is based on a 70-year lifetime exposure. Infants are exposed for only 1 year, during which exposure concentrations will be at a maximum. In order to prevent underestimating carcinogenic risk based on exposure as an infant, maximum soil concentrations were used instead of average soil concentrations in calculating the mother's

intake and resultant carcinogenic risk to the infant. Maximum soil concentrations also were used to calculate noncarcinogenic risk to an infant, child, or adult, since it is possible that any individual may be exposed to maximum soil concentrations. More detailed information on soil concentrations is presented in Appendix 8A.

The air pathway was evaluated for all of the pollutants of concern as identified in Section 7. The pollutants that were evaluated for the soil pathway were chosen based on the physical characteristics of chemicals as well as a comparison to background levels. This screening process is described in greater detail in Section 7. In screening pollutants for the surface water pathway, a worst case (Tier 1) approach was used to calculate surface water pollutant concentrations. However, in order to determine more realistic levels of exposure through the surface water pathway, a Tier 2 evaluation was conducted. The details of this methodology, including the predicted surface water concentrations of the pollutants of concern, are presented in Appendix 7A.

8.2 ROUTES OF EXPOSURE CONSIDERED FOR THE ADULT

The routes of exposure evaluated for adults are discussed below. All tables containing exposure doses calculated for the adult, based on the Resident-A, Resident-B, Farmer, and Worker exposure scenarios, are presented at the end of Section 8.

8.2.1 Adult Inhalation Exposure

As discussed in Section 7, inhalation exposure was estimated for all pollutants of concern. For the inhalation pathway, the total duration of exposure for an adult was assumed to be continuous over the facility lifetime. Thus, inhalation exposure to adults under the Resident-A, Resident-B, and Farmer scenarios was assumed to occur for 365 days per year for 2 years. Inhalation exposure to workers would occur for 250 days per year, based on a 5-day work week for 50 weeks per year. It was assumed that indoor air exposure was equivalent to outdoor exposure. This assumption is likely to lead to an overestimation of

exposure because indoor concentrations resulting from air-dispersed, outdoor-generated pollutants will most likely be lower than the outdoor concentrations.

Based on these assumptions, the following equation was used to calculate the estimated daily intake through inhalation:

$$Intake_{inh} = \frac{C_{air} \times IR \times EF}{BW \times F}$$

Where:

$Intake_{inh}$ = Estimated daily intake through inhalation (mg pollutant/kg body weight/day)

C_{air} = Pollutant concentration in ambient air ($\mu g/m^3$)

IR = Inhalation rate for an adult:

- 20 m^3/day - Resident-A, Resident-B, and Farmer scenarios (Woodward-Clyde, 1990b)
- 10 m^3/day - Worker scenario (Ebasco, 1990)

EF = Exposure frequency:

- 365 days/yr - Resident-A, Resident-B, and Farmer scenarios
- 250 days/yr - Worker scenario

BW = Body weight for an adult, 70 kg (Ebasco, 1990)

F = Conversion factor: 10^3 $\mu g/mg$; 365 days/yr

Predicted ambient air concentrations for the Resident-A, Resident-B, Farmer, and Worker scenarios were calculated in the modeling analysis and are presented in Table 8-3. The estimated daily intakes through the inhalation exposure route are presented in Tables 8-4

and 8-5 for the Resident-A scenario, Tables 8-6 and 8-7 for the Resident-B scenario, Tables 8-8 and 8-9 for the Farmer scenario, and Tables 8-10 and 8-11 for the Worker scenario.

8.2.2 Adult Ingestion Exposure

The ingestion of vegetables, milk, beef, soil/dust, and fish are discussed in the following subsections. All of these ingestion routes of exposure were evaluated for the Resident-A, Resident-B, and Farmer scenarios. Only the soil/dust ingestion route was evaluated for the Worker scenario.

8.2.2.1 Vegetable Consumption

Vegetables and fruits from home vegetable gardens can be potentially contaminated by airborne pollutants emitted from the SQI. Three locally grown food crops were selected to identify potential exposure to pollutants through vegetable/fruit ingestion. Carrots were selected to represent a root vegetable, lettuce to represent a leafy vegetable, and tomatoes to represent a fruiting vegetable or vine crop. Ingestion rates were based on the average daily consumption of these food groups. For example, the carrot ingestion rate was based on the consumption of all root vegetables; the lettuce ingestion rate was based on the consumption of all leafy vegetables; and the tomato ingestion rate was based on the consumption of fruiting vegetables. This simplified the exposure calculation while taking into account all vegetables potentially consumed from household gardens. The ingestion rates used in this assessment were based on EPA (1990a) estimates.

For the Resident-A and Resident-B scenarios, it was assumed that 58 percent of all vegetables consumed were homegrown or obtained from a local source. This percentage is based on data for rural households (ESE et al., 1989). For the Farmer scenario it was assumed that 90 percent of all vegetables consumed were homegrown (EPA, 1990b).

Consistent with the analysis in this report of other soil-related exposure pathways, the contaminant soil concentrations were based on deposition determined over the 2-year life of the incinerator. Soil concentrations were calculated as described in Appendix 8A, using a mixing depth of 20 cm to account for soil cultivation (EPA, 1986).

Pollutants may contaminate plants through two principal mechanisms: absorption through root uptake from contaminated soil and direct deposition on aboveground parts of the plants (leaves, fruits, stems). Deposition on the aboveground section of the plant (tomatoes and lettuce only) will occur primarily in the form of dry deposition, which will uniformly cover all exposed surfaces. It was conservatively assumed that all dry deposition on the plant surface during the growing season was retained and was not washed off by rain events. Dry deposition rates are presented in Appendix 8B, Tables 8B-8 through 8B-19. However, it was also assumed that wet deposition was not retained on the plant and ran off the plant surface to the ground, even though it is likely that some wet deposition would be retained on plants after a rain event. Although this is not a conservative assumption, it tends to offset the previous assumption that all dry deposition is retained on the plant surface.

The following subsections discuss the methodology that was used to calculate pollutant exposure through vegetable ingestion. The average and maximum daily intakes of pollutants through total vegetable ingestion are summarized in Tables 8-4 and 8-5 for the Resident-A scenario, Tables 8-6 and 8-7 for the Resident-B scenario, and Tables 8-8 and 8-9 for the Farmer scenario. Intermediate calculations used to determine total vegetable intakes, as well as intakes for the individual vegetables, are presented in Appendix 8B.

Root Vegetables — The carrot, which is an edible taproot, served as a surrogate for root vegetables grown in home gardens. Thus, the carrot ingestion rate was based on the consumption of all root vegetables for the Farmer scenario. For the Resident-A and Resident-B scenarios, the root vegetable intakes were assumed not to include potatoes, since it is unlikely that residents would grow potatoes in their home gardens.

Carrots were assumed to accumulate pollutants only through uptake from the soil. The absorption of pollutants deposited on the leaves, and their subsequent translocation to the root, were assumed to be negligible (Wipf et al., 1982). It also was assumed that the carrots would be washed before consumption, so that the adherence of soil to the carrots would not contribute to pollutant intake.

The general formulas used to calculate exposure through carrot ingestion include the calculation of the pollutant concentration in the carrot:

$$C_{Carrot} = C_{Soil} \times RUF;$$

and the calculation of the estimated intake due to the consumption of carrots:

$$Intake_{Car} = \frac{C_{Carrot} \times IR \times HG \times F}{BW}$$

Where:

$Intake_{Car}$ = Estimated daily intake due to consumption of carrots (mg pollutant/kg body weight/day), Appendix 8B

C_{Carrot} = Pollutant concentration in the carrot (mg/kg), Appendix 8B

C_{Soil} = Pollutant concentration in the soil (mg/kg), Appendix 8B

RUF = Root uptake factor (dimensionless), Appendix 8B

IR = Ingestion rate (wet weight), average adult daily consumption of root vegetables (EPA, 1990a):

- 11.7 g/day - Resident-A and Resident-B scenarios
- 65.3 g/day - Farmer scenario

HG = Fraction homegrown:

- 58 percent - Resident-A and Resident-B scenarios (ESE et al., 1989)
- 90 percent - Farmer scenario (EPA, 1990b)

F = Conversion factor, 10^{-3} kg/g

BW = Body weight, average adult (70 kg) (Ebasco, 1990)

The root uptake factor (RUF) is defined as the ratio of the concentration of the pollutant in the root (C_{root}) to the concentration in the soil (C_{soil}). The formulation of a RUF assumes that plant uptake is proportional to soil concentrations. The derivation of the RUFs used for this assessment is described in Appendix 8B.

Calculation of Daily Intake — Factors used in the calculation of pollutant concentrations in carrots are summarized in Appendix 8B. The wet weight ingestion rates of 11.7 g/day for the Resident-A and Resident-B scenarios and 65.3 g/day for the Farmer scenario were calculated from dry weight ingestion rates for root vegetables (the former of which excludes potatoes) (EPA, 1990a), assuming a moisture content of 77.8 percent for potatoes and 88 percent for all other root vegetables (Baes et al., 1984). The ingestion rates were based on the average dry weight ingestion rates for individuals over the age of 13 years of 0.02 g/kg body weight/day (Resident-A and -B) and 0. 19 g/kg body weight/day (Farmer), respectively. Average and maximum daily intakes of pollutants through root vegetable ingestion for the adult are summarized in Appendix 8B. Average and maximum daily intakes of pollutants through total vegetable ingestion (i.e., root, leafy, and fruiting vegetables) are summarized in Tables 8-4 and 8-5, Tables 8-6 and 8-7, and Tables 8-8 and 8-9 for the Resident-A, Resident-B, and Farmer scenarios, respectively.

Leafy and Fruiting Vegetables — Consumption of leafy and fruiting vegetables grown in home gardens was represented by lettuce and tomatoes, respectively. Root uptake of pollutants from the soil and the surface deposition of pollutants on edible aboveground plant parts were used to determine the accumulation of pollutants by lettuce and tomatoes. The formulas used to calculate the exposure to pollutants through the ingestion of these vegetables are as follows:

$$C_{Tomato\ (Lettuce)} = C_{Surface} + C_{Uptake}$$

$$Intake_{Tomato\ (Lettuce)} = \frac{C_{Tomato\ (Lettuce)} \times IR \times HG \times F}{BW}$$

Where:

$Intake_{Tomato\ (Lettuce)}$ = Estimated daily intake due to consumption of leafy vegetables or vine crops (mg pollutant/kg body weight/day), Appendix 8B

$C_{Tomato\ (Lettuce)}$ = Pollutant concentration in leafy or fruiting vegetables (mg/kg), Appendix 8B

$C_{surface}$ = Pollutant concentration in plant due to surface deposition (mg/kg), Appendix 8B

C_{Uptake} = Pollutant concentration in plant due to root uptake (mg/kg), Appendix 8B

IR = Ingestion rate, daily consumption of leafy or fruiting vegetables (EPA, 1990a):

- 64 g/day - Tomatoes
- 11.9 g/day - Lettuce

HG = Fraction homegrown:

- 58 percent - Resident-A and Resident-B scenarios (ESE et al., 1989)
- 90 percent - Farmer scenario (EPA, 1990b)

F = Conversion factor, 10^{-3} kg/g

BW = Body weight, average adult (70 kg) (Ebasco, 1990)

Plant pollutant concentrations due to surface deposition and root uptake are presented and described in Appendix 8B.

Calculation of Daily Intakes — Total pollutant concentrations in tomatoes and lettuce were determined by adding the concentrations due to deposition and root uptake and are summarized in Appendix 8B. The ingestion rates used for lettuce (11.9 g/day) and tomatoes (64 g/day) were wet weight ingestion rates for leafy and fruiting vegetables, respectively. These values were calculated from dry weight ingestion rates for leafy vegetables (0.008 g/kg body weight/day) and fruiting vegetables (0.06 g/kg body weight/day) for individuals over the age of 13 years (EPA, 1990a), assuming a moisture content of 95 percent for lettuce and 94 percent for tomatoes (Baes et al., 1984). Average and maximum daily intakes of pollutants for all exposure scenarios through tomato and lettuce ingestion for the adult are summarized in Appendix 8B. The estimated daily intake through total vegetable ingestion was calculated by the following equation:

$$Intake_{Veg} = (Intake_{Carrots} + Intake_{Tomatoes} + Intake_{Lettuce})$$

Average and maximum daily intakes of pollutants through total vegetable ingestion (i.e., root, leafy, and fruiting vegetables) are summarized in Tables 8-4 and 8-5, Tables 8-6 and 8-7, and Tables 8-8 and 8-9 for the Resident-A, Resident-B, and Farmer scenarios, respectively.

Several assumptions that contributed to the conservatism of the dosage estimates were made in the computation of pollutant exposure through vegetable ingestion. These assumptions included:

- No degradation of pollutants on plant surfaces via photolysis or volatilization occurred.
- Tomatoes and lettuce were not washed before consumption.
- Vegetables grown at the Resident-A, Resident-B, or Farmer scenario locations were consumed daily over an entire lifetime.

8.2.2.2 Consumption of Dairy and Beef Products from Local Farms

A number of dairy and beef cattle were observed in the vicinity of RMA. The potential for indirect human exposure to pollutants may occur when farm animals near the incinerator site consume feed and/or ingest soil during grazing or feeding. These pollutants may then be incorporated into beef or dairy products that are consumed by human receptors. The consumption of beef and dairy products was evaluated for the Resident-A, Resident-B, and Farmer scenarios.

Two farm products (milk and beef) were selected to investigate the potential for pollutant uptake by humans. The highest exposure would be expected for farmers who consume their own animals (beef) or animal products (milk). Exposure of the general public might occur if beef or dairy products were obtained from a local farmer, but would be expected to be lower than exposure for farmers. It was assumed that a subsistence farmer would home produce 100 percent of all meat and milk consumed. For the Resident-A and Resident-B scenarios, it was assumed that 5 percent of all meat and milk consumed was obtained from a local source.

Four major types of feed are consumed by dairy and beef cattle raised in the vicinity of RMA: hay, corn silage, grain, and pasture grass (Stanton, 1990). The dietary intakes of each type of feed for these animals are discussed in Appendix 8C. Although some beef and dairy cattle raised in the area are grazed, lactating dairy cows and finishing stock are not, and thus, the ingestion of pasture grass and incidental soil was not evaluated as part of the cattle diet. The cattle, as well as the cattle feed, were assumed to be raised at the same location for all scenarios. This location was chosen based on the area of highest deposition and air concentration where cows were observed grazing.

The methods used to calculate the pollutant concentrations in cattle feed were the same as those used for tomatoes and lettuce. They are described in Appendix 8C. These include the

direct deposition of airborne pollutants on plant surfaces and root uptake of pollutants from soil.

The final step is to determine the human exposure due to the consumption of dairy and beef products. This was calculated as follows:

$$Intake_{Milk\ (beef)} = \frac{C_{Milk\ (beef)} \times IR \times HG \times F}{BW}$$

Where:

$Intake_{Milk\ (beef)}$	=	Estimated daily intake resulting from the ingestion of milk or beef (mg pollutant/kg body weight/day)
$C_{Milk\ (beef)}$	=	Pollutant concentration in the milk or beef (mg/kg), Appendix 8C
IR	=	Ingestion rate, average daily adult consumption of milk or beef (g/day) (Fries, 1986; Pao et al., 1982)
HG	=	Fraction homegrown: • 5 percent - Resident-A and Resident-B scenarios • 100 percent - Farmer scenarios
F	=	Conversion factor, 10^{-3} kg/g
BW	=	Body weight, average adult (70 kg) (Ebasco, 1990)

Factors used to calculate pollutant concentrations in milk and beef are summarized in Appendix 8C. The average milk consumption rate for an adult was estimated to be 305 g/day (Fries, 1986), and the average beef consumption rate was estimated to be 66.8 g/day (Fries, 1986). The consumption rates of milk fat and beef fat are used in calculating dioxin intake (Appendix 8C). Since the fat content of whole milk is about 4 percent, the daily consumption equates to about 12 g of milk fat/day for an adult. Fat content varies greatly between different cuts of beef. However, the most recent available data show that the average percentage of beef fat ingested by adults is 22 percent (Fries, 1986). This

corresponds to an average daily intake of 14.7 g of beef fat/day. Average and maximum daily intake rates of pollutants through milk and beef consumption are presented in Tables 8-4 and 8-5 for the Resident-A scenario, Tables 8-6 and 8-7 for the Resident-B scenario, and Tables 8-8 and 8-9 for the Farmer scenario.

8.2.2.3 Soil/Dust Ingestion

The potential for oral intake of pollutants by older children and adults through soil/dust ingestion was calculated using the following formula:

$$Intake_{Soil/dust} = \frac{C_{Soil} \times IR \times EF \times F}{BW}$$

Where:

$Intake_{Soil/dust}$ = Estimated daily intake due to soil/dust ingestion (mg pollutant/kg body weight/day)

C_{Soil} = Pollutant concentration in soil (mg/kg)

IR = Ingestion rate, average adult daily ingestion of soil and dust:

- 0.1 g/day - Resident-A, Resident-B, Farmer, and Worker scenarios (EPA, 1990b; Ebasco, 1990)

EF = Exposure frequency:

- 365 days/year - Resident-A, Resident-B, and Farmer scenarios
- 225 days/year - Worker scenario (U.S. Army, 1990b)

F = Conversion factors: 10^{-3} kg/g, yr/365 days

BW = Body weight, average adult (70 kg) (Ebasco, 1990).

It was assumed that adults could be exposed to outdoor soils during a variety of outdoor activities such as farming, gardening, yard work, or maintenance work. Although exposure to a mixture of tilled and untilled soils might occur, the untilled soil (10-cm mixing depth) was used as a more conservative estimate of soil exposure. It was assumed that the concentrations of pollutants in indoor dusts were the same as those in the soil, since indoor dust is generally believed to be derived, at least in part, from soil from outdoor sources. Predicted average and maximum concentrations for the pollutants of concern in the top 10 cm of soil are listed for the exposure scenarios in Appendix 8A. These concentrations are based on the total deposition for each scenario location.

An annual average soil/dust ingestion rate of 100 mg/day was assumed for adults under the Resident-A, Resident-B, and Farmer scenarios (EPA, 1990b). This soil/dust ingestion rate is based on a 365-day-per-year exposure. The worker was also assumed to ingest 100 mg/day of soil/dust on those days when he is in direct contact with soil (Ebasco, 1990). It was assumed that a road and grounds crew worker would spend 90 percent of his time outside (U.S. Army, 1990b). This amounts to 225 days per year based on a 5-day work week for 50 weeks per year.

Average and maximum daily intakes of pollutants through soil/dust ingestion are presented in Tables 8-4 and 8-5 for the Resident-A scenario, Tables 8-6 and 8-7 for the Resident-B scenario, Tables 8-8 and 8-9 for the Farmer scenario, and Tables 8-10 and 8-11 for the Worker scenario. The parameters used in the calculations for adult soil/dust ingestion are presented in Appendix 8D.

8.2.2.4 Fish Consumption

Those who are most likely to be exposed to pollutants through fish consumption are local residents who use waters in the vicinity of the SQI for recreational fishing. Engineers Lake, a recreational fishery about 8 km west of the facility, was selected for analysis because it was expected to have maximum surface water concentrations of pollutants. This was based on

likely extended pollutant retention times as well as the impact of direct deposition and watershed area. Fish consumption was evaluated for the Resident-A, Resident-B, and Farmer scenarios.

A fish ingestion rate was derived from data taken from a fisherman survey and creel census taken at lakes, reservoirs, and rivers in the RMA area (northeast Colorado). An average fish consumption rate of 4.84 g/day was used for adults based on data for harvest rates of nontrout warm-water species and the amount of time anglers spend fishing (ESE et al., 1989).

The daily intakes of pollutants through fish consumption were estimated using the following formulas:

$$C_{Fish} = C_{Water} \times BCF$$

$$Intake_{Fish} = \frac{C_{fish} \times IR \times F}{BW}$$

Where:

$Intake_{Fish}$ = Estimated daily intake due to fish ingestion (mg/kg-day)

C_{Fish} = The equilibrium concentration of the pollutant in fish from Engineers Lake (mg/kg)

C_{Water} = Surface water concentration in Engineers Lake (mg/L), see Appendix 7A

BCF = Bioconcentration factor (L/kg), Appendix 8E

IR = Ingestion rate, average daily fish consumption rate (4.84 g/day) (ESE et al., 1989)

F = Conversion factor (10^{-3} kg/g)

BW = Body weight, average adult (70 kg) (Ebasco, 1990)

Bioconcentration factors (BCFs) for the pollutants of concern, as well as all parameters used to calculate daily pollutant intakes from fish ingestion, are presented in Appendix 8E.

The estimated daily intake of organic contaminants due to fish ingestion was modified to account for the lipid content in the edible portion relative to that of the whole body of the fish. It was assumed that 10 percent of the fish lipid content would be found in the fillet. This modification was made only for organic compounds since they concentrate in areas of high lipid content.

The estimated daily intakes of pollutants through fish consumption are summarized in Tables 8-4 and 8-5 for the Resident-A scenario, Tables 8-6 and 8-7 for the Resident-B scenario, and Tables 8-8 and 8-9 for the Farmer scenario. Because individuals for all scenarios are assumed to fish in Engineers Lake, the estimated intakes are the same for all exposure scenarios.

8.2.3 Adult Dermal Exposure

This subsection estimates the potential pollutant intake due to dermal absorption from soils. For adults, dermal exposure is assumed to occur during outdoor activities such as farming, gardening activities, yard work, and maintenance work.

The following equation was used to calculate the dermal dose:

$$Intake_{Derm} = \frac{C_{Soil} \times ABS \times AF \times SMF \times SA \times EF \times F}{BW}$$

Where:

$Intake_{Derm}$ = Estimated daily intake due to dermal exposure to soil (mg pollutant/kg body weight/day)

C_{Soil} = Pollutant concentration in soil (mg/kg), Appendix 8A

ABS = Absorption factor:

- 10 percent - organics (Ebasco, 1990)
- 1 percent - inorganics (Ebasco, 1990)

AF = Soil to skin adherence factor:

- 0.51 mg/cm^2 - Resident-A and Resident-B scenarios (Ebasco, 1990)
- 1.5 mg/cm^2 - Farmer and Worker scenarios (Ebasco, 1990)

SMF = Soil matrix factor (1.0) (Ebasco, 1990)

SA = Skin surface area available for contact:

- 4,500 cm^2 - Resident and Farmer scenarios (Ebasco, 1990)
- 3,200 cm^2 - Worker scenario (Ebasco, 1990)

EF = Exposure frequency, i.e., total number of exposures per year:

- 117 days/year - Resident-A and Resident-B scenarios
- 195 days/year - Farmer and Worker scenarios

F = Conversion factor: 10^{-6} kg/mg, year/365 days

BW = Body weight, average adult (70 kg) (Ebasco, 1990)

Dermal exposure was assumed to occur during the warmer two-thirds of the year (i.e., approximately 35 weeks per year). Both the farmer and maintenance worker, who tend to spend a greater than average time outside, were assumed to be dermally exposed 5 days per week. Residents were assumed to spend less time involved in outdoor activities, and so were evaluated based on a dermal exposure contact rate of 3 times per week. Both the farmer and worker, therefore, were assumed to be exposed for 195 days per year, and the residents for 117 days per year. A soil adherence factor of 1.5 mg/cm^2 was assumed for the farmer and the maintenance worker (Ebasco, 1990). A lower soil adherence factor (0.51 mg/cm^2) was assumed for the residents based on a study of children in Hartford (Ebasco,

1990). The exposed skin surface area for the worker was assumed to include the head, neck, forearms, and hands, or 3,200 cm^2 of exposed skin. The farmer and resident were assumed to have 4,500 cm^2 of exposed skin, which includes one-half of the head, hands, forearms, and lower legs (Ebasco, 1990).

Absorption of contaminants from soil may be inhibited by physical-chemical bonding to the matrix, in addition to the fact that only a small amount of the contaminant is in direct contact with the skin. However, for this assessment, no bonding to the matrix was assumed to occur, and, thus, a soil matrix factor of 1.0 was assumed (Ebasco, 1990).

Dermal absorption factors of 10 percent for organic pollutants and 1 percent for inorganic pollutants were used. These values were selected to represent the differential absorption of organic and inorganic pollutants (Ebasco, 1990).

Predicted average concentrations for the pollutants of concern in the uppermost 10 cm of soil are listed for the exposure scenarios in Appendix 8A. These concentrations are based on the total deposition for each scenario location. The parameters that were used in the calculations for adult dermal exposure are given in Appendix 8F.

The estimated pollutant intakes resulting from dermal exposure due to soil contact are summarized in Tables 8-4 and 8-5 for the Resident-A scenario, Tables 8-6 and 8-7 for the Resident-B scenario, Tables 8-8 and 8-9 for the Farmer scenario, and Tables 8-10 and 8-11 for the Worker scenario.

Table 8-2 summarizes the exposure assumptions used for the adult in estimating total daily intakes. Exposure assumptions used for the child and the infant are also included in this table and are discussed in more detail in the following subsection.

8.3 ROUTES OF EXPOSURE CONSIDERED FOR CHILDREN AND INFANTS

Children and infants were evaluated in the Resident-A, Resident-B, and Farmer exposure scenarios. Children were assumed to be exposed to pollutants through the pathways of exposure as adults (Subsection 8.2). Infants were assumed to be exposed to pollutants only by the ingestion of mother's milk and the inhalation pathway.

Childhood exposure in this assessment was assumed to occur in children 1 to 6 years old. The average weight of a child between 1 and 6 years old was estimated to be 15.5 kg (Ebasco, 1990). The average weight of an infant age 0 to 1 was estimated to be 9 kg (EPA, 1989b). Other infant and childhood factors specific to individual routes of exposure are presented in the subsections that follow. All exposure doses calculated for children and infants, based on the Resident-A, Resident-B, and Farmer scenarios, are presented at the end of Subsection 8.3. All of the exposure assumptions are presented in Table 8-2.

8.3.1 Children and Infant Inhalation Exposure

Childhood and infant inhalation exposure was calculated using the methodology described for adult inhalation (Subsection 8.2.1). It was assumed that childhood inhalation exposure was continuous for the 2-year lifetime of the facility, and infant exposure was continuous for 1 year. The average inhalation rate for children, 1 to 6 years old, was estimated to be 10 m^3/day (NRC, 1977), and the average inhalation rate for infants, 0 to 1 year, was estimated to be 3.8 m^3/day (NCRP, 1984). Predicted ambient air concentrations for the three exposure scenarios (Resident-A, Resident-B, and Farmer) are presented in Table 8-3. The estimated childhood intakes due to inhalation are presented in Tables 8-12 and 8-13 for the Resident-A scenario, Tables 8-14 and 8-15 for the Resident-B scenario, and Tables 8-16 and 8-17 for the Farmer scenario. The estimated infant intakes due to inhalation are presented in Table 8-18 for the Resident-A scenario, Table 8-19 for the Resident-B scenario, and Table 8-20 for the Farmer scenario.

8.3.2 Children Ingestion Exposure

8.3.2.1 Vegetable, Milk, Beef, Soil/Dust, and Fish Consumption

Childhood ingestion exposure was calculated using the same methodology described for the adult (Subsection 8.2.2). Food and soil/dust ingestion rates specific to children 1 to 6 years old are presented in Table 8-2. It should be noted that soil/dust ingestion rates for young children are higher than those for older children and adults. Soil/dust ingestion in young children can occur indirectly by placing dirt-covered hands or objects in the mouth, or in some cases, by directly eating soil. The soil concentrations used in the exposure calculations are presented in Appendix 8A.

Total average and maximum daily intakes for children for all ingestion routes of exposure are summarized at the end of Section 8 in Tables 8-12 and 8-13 for the Resident-A scenario, Tables 8-14 and 8-15 for the Resident-B scenario, and Tables 8-16 and 8-17 for the Farmer scenario. The parameters used in the calculations for child vegetable consumption, milk and beef consumption, soil/dust ingestion, and fish consumption are presented in Appendices 8B, 8C, 8D, and 8E, respectively.

8.3.3 Dermal Absorption By Children

This subsection estimates the potential childhood pollutant intake due to the dermal absorption of pollutants from soils. The methodology used to calculate the dermal intake of pollutants in children was the same as that described for adults in Subsection 8.2.3. Only the specific input parameters used to calculate doses for children are discussed in the following paragraphs.

As with the adult, it was assumed that dermal exposure would occur during the warmer two-thirds of the year, or approximately 35 weeks per year. Also, it was assumed that children, on the average, would spend 5 days per week outside, resulting in a total of 195 dermal exposure events per year. A soil adherence factor of 0.51 mg/cm^2 was used based on a

study of children in Hartford (Ebasco, 1990). The area of exposed skin averaged for 1 through 6 year-olds was estimated to be 2,500 cm^2 (Ebasco, 1990).

The concentrations of pollutants in the uppermost 10 cm of soil were previously calculated (Appendix 8A). The estimated dosages of pollutants to children through dermal exposure are summarized at the end of Section 8 in Tables 8-12 and 8-13 for the Resident-A scenario, Tables 8-14 and 8-15 for the Resident-B scenario, and Tables 8-16 and 8-17 for the Farmer scenario. The parameters used in the calculations for child dermal exposure are presented in Appendix 8F.

8.3.4 Infant Consumption of Mother's Milk

The intake of pollutants by infants through breast milk consumption was addressed for the organic pollutants of concern. There were insufficient data available in the surveyed literature to quantify the potential transfer of inorganic pollutants into human breast milk.

The estimated daily intakes of organic pollutants through breast milk ingestion were determined using the following equation:

$$Intake_{Bmilk} = \frac{C_{Bmilk} \times IR}{BW}$$

Where:

$Intake_{Bmilk}$ = Estimated daily intake resulting from the ingestion of breast milk (mg/kg-day)

C_{Bmilk} = Concentration of the pollutant in breast milk (mg/kg), Appendix 8G

IR = Breast milk ingestion rate (0.8 kg/day) (Smith, 1987)

BW = Body weight, infant 0 to 1 year (9 kg) (EPA, 1989b)

Factors used in the calculation of pollutant concentrations in breast milk are more fully discussed in Appendix 8G. An infant was assumed to ingest 0.8 kg/day of breast milk (Smith, 1987), and to breast feed for 1 year. A body weight of 9 kg, the average body weight of children less than 1 year of age, was used (EPA, 1989b).

The maximum estimated daily intakes of pollutants for infants through breast milk ingestion exposure are summarized in Table 8-18 for the Resident-A scenario, Table 8-19 for the Resident-B scenario, and Table 8-20 for the Farmer scenario. Average daily intakes were not calculated for the infant; maximum daily intakes were used in calculation of both carcinogenic risk and noncarcinogenic health effects for the infant.

SECTION 8

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Table 8-1

Overview of Exposure Scenarios

Resident-A Scenario	Resident-B Scenario	Farmer Scenario	Worker Scenario
Receives maximum off-site inhalation exposure of vapors and particulates.	Receives inhalation of vapor and particulates determined at the maximum wet/total deposition location.	Receives inhalation of vapors and particulates determined at the farm location.*	Receives inhalation of vapors and particulates determined at the arsenal.
Eats vegetables grown at the maximum off-site dry deposition location.	Eats vegetables grown at the maximum off-site wet/total deposition location.	Eats vegetables grown at the farm location.*	Contacts soil at the arsenal.
Eats beef and drinks milk from cattle raised at the farm location.*	Eats beef and drinks milk from cattle raised at the farm location.*	Eats beef and drinks milk from cattle raised at the farm location.*	Ingests indoor dust and outdoor soil at the arsenal.
Contacts soil at the maximum off-site dry deposition location.	Contacts soil at the maximum off-site wet/total deposition location.	Contacts soil at the farm location.*	
Ingests indoor dust and outdoor soil at the maximum off-site dry deposition location.	Ingests indoor dust and outdoor soil at the maximum off-site wet/total deposition location.	Ingests indoor dust and outdoor soil at the farm location.*	
Eats fish from Engineers Lake.	Eats fish from Engineers Lake.	Eats fish from Engineers Lake.	
Consumes breast milk as an infant.	Consumes breast milk as an infant.	Consumes breast milk as an infant.	

*A farm was assumed to be located where deposition (wet and dry) and air concentration are highest for that land use.

Table 8-2

Exposure Parameters Used for Adult, Child, and Infant for the Various Scenarios

Pathways and Parameters	Worker Scenario	Farmer Scenario -Adult	Farmer Scenario -Child	Resident-A and Resident-B Scenarios -Adult	Resident-A and Resident-B Scenarios -Child	Resident-A and -B and Farmer Scenarios-Infant
AIR PATHWAY						
• Breathing rate	10 m^3/day (Ebasco, 1990)	20 m^3/day (Woodward-Clyde, 1990b)	10 m^3/day (NRC, 1977)	20 m^3/day (Woodward-Clyde, 1990b)	10 m^3/day (NRC, 1977)	3.8 m^3/day (NCRP, 1984)
• Exposure frequency	250 days/yr[a]	365 days/yr	365 days/yr	365 days/yr	365 days/yr	365 days/yr
SOIL PATHWAY						
• Soil/dust ingestion rate	100 mg/day (Ebasco, 1990)	100 mg/day (EPA, 1990b)	200 mg/day (EPA, 1990b)	100 mg/day (EPA, 1990b)	200 mg/day (EPA, 1990b)	---
• Exposure frequency for soil ingestion	225 days/yr[b]	365 days/yr	365 days/yr	365 days/yr	365 days/yr	---
• Skin surface area	3,200 cm^2 [c] (Ebasco, 1990)	4,500 cm^2 [d] (Ebasco, 1990)	2,500 cm^2 (Ebasco, 1990)	4,500 cm^2 (Ebasco, 1990)	2,500 cm^2 (Ebasco, 1990)	---
• Soil adherence factor	1.5 mg/cm^2 (Ebasco, 1990)	1.5 mg/cm^2 (Ebasco, 1990)	0.51 mg/cm^2 (Ebasco, 1990)	0.51 mg/cm^2 (Ebasco, 1990)	0.51 mg/cm^2 (Ebasco, 1990)	--
• Soil matrix factor	1.0 (Ebasco, 1990)	1.0 (Ebasco, 1990)	1.0 (Ebasco, 1990)	1.0 (Ebasco, 1990)	1.0 (Ebasco, 1990)	---

Table 8-2
Exposure Parameters Used for Adult, Child, and Infant for the Various Scenarios (Continued)

Pathways and Parameters	Worker Scenario	Farmer Scenario -Adult	Farmer Scenario -Child	Resident-A and Resident-B Scenarios -Adult	Resident-A and Resident-B Scenarios -Child	Resident-A and -B and Farmer Scenarios-Infant
SOIL PATHWAY						
• Dermal absorption	0.01 (metals) 0.10 (organics) (Ebasco, 1990)	0.01 (metals) 0.10 (organics) (Ebasco, 1990)	0.01 (metals) 0.10 (organics) (Ebasco, 1990)	0.01 (metals) 0.10 (organics) (Ebasco, 1990)	0.01 (metals) 0.10 (organics) (Ebasco, 1990)	---
• Exposure frequency for dermal contact	195 days/yr[e]	195 days/yr[e]	195 days/yr[e]	117 days/yr[f]	195 days/yr[f]	---
• Vegetable Ingestion rate -Root -Fruiting -Leafy	 --- --- ---	 65.3 g/day[g] 64 g/day 11.9 g/day (EPA, 1990a)	 31.1 g/day[g] 33.6 g/day 1.24 g/day (EPA, 1990a)	 11.7 g/day[h] 64 g/day 11.9 g/day (EPA, 1990a)	 3.88 g/day[h] 33.6 g/day 1.24 g/day (EPA, 1990a)	---
• Percent Vegetables home-grown	---	90% (EPA, 1990b)	90% (EPA, 1990b)	58% (ESE et al., 1989)	58% (ESE et al., 1989)	---
SOIL PATHWAY						
• Milk ingestion rate	---	305 g/day (Fries, 1986)	390 g/day (Pao et al., 1982)	305 g/day (Fries, 1986)	390 g/day (Pao et al., 1982)	800 g/day[i] (Smith, 1987)
• Milk fat ingestion rate	---	11 g/day (Fries, 1986)	16 g/day (EPA, 1986)	11 g/day (Fries, 1986)	16 g/day (EPA, 1986)	---
• Percent milk home or locally produced	---	100%[j]	100%[j]	5%	5%	---
• Beef ingestion rate	---	67 g/day (Fries, 1986)	37 g/day (Pao et al., 1982)	67 g/day (Fries, 1986)	37 g/day (Pao et al., 1982)	---

Table 8-2
Exposure Parameters Used for Adult, Child, and Infant for the Various Scenarios (Continued)

Pathways and Parameters	Worker Scenario	Farmer Scenario -Adult	Farmer Scenario -Child	Resident-A and Resident-B Scenarios -Adult	Resident-A and Resident-B Scenarios -Child	Resident-A and -B and Farmer Scenarios-Infant
• Beef fat ingestion rate	---	15 g/day (Fries, 1986)	9 g/day (EPA, 1986)	15 g/day (Fries, 1986)	9 g/day (EPA, 1986)	---
• Percent beef home or locally produced	---	100%[j]	100%[j]	5%	5%	---
• Fish ingestion rate	---	4.84 g/day (ESE et al., 1989)	2.42 g/day[k]	4.84 g/day (ESE et al., 1989)	2.42 g/day[k]	---
ALL PATHWAYS						
• Body weight	70 kg (Ebasco, 1990)	70 kg (Ebasco, 1990)	15.5 kg (Ebasco, 1990)	70 kg (Ebasco, 1990)	15.5 kg (Ebasco, 1990)	9 kg (EPA, 1989b)

[a]Based on continuous exposure over a 5-day work week for 50 weeks out of the year.
[b]It was assumed that 90 percent of a work year (5 days/wk, 50 wks/yr) was spent outside (Don Marlow, Chief of Maintenance, Rocky Mountain Arsenal, personal communication, 1990).
[c]Based on exposure to hands, forearms, head, and neck.
[d]Based on exposure to one-half of the head, hands, forearms, and lower legs.
[e]Based on exposure for 5 days per week, 35 weeks per year. It was assumed that during the colder months, dermal exposure would be insignificant due to such factors as snow-cover, frozen ground, and greatly reduced exposed skin surface area.
[f]Based on exposure for 3 days per week, 35 weeks per year. It was assumed that during the colder months, dermal exposure would be insignificant due to such factors as snow cover, frozen ground, and greatly reduced exposed skin surface area.
[g]This root ingestion rate includes potatoes.
[h]This root ingestion rate excludes potatoes.
[i]Based on breast milk consumption.
[j]It was assumed that a subsistence farmer would consume 100 percent of home-produced milk and beef.
[k]Assumed to be one-half the adult fish ingestion rate.

Table 8-3

Predicted Ambient Air Concentrations

Pollutant	Predicted Average Annual Concentration ($\mu g/m^3$)			
	Resident-A	Resident-B	Farmer	Worker
ORGANICS				
Benzene	4.35E-06	8.63E-07	1.51E-06	1.30E-06
Benzoic Acid	1.80E-05	3.58E-06	6.27E-06	5.40E-06
Bis(2-ethylhexyl)phthalate	6.84E-06	1.36E-06	2.38E-06	2.05E-06
Bromodichloromethane	1.51E-05	2.99E-06	5.25E-06	4.51E-06
Butylbenzylphthalate	4.81E-06	9.54E-07	1.67E-06	1.44E-06
Carbon Tetrachloride	3.97E-06	7.86E-07	1.38E-06	1.19E-06
Chlorobenzene	3.86E-06	7.66E-07	1.34E-06	1.15E-06
Chloroform	6.88E-05	1.36E-05	2.39E-05	2.06E-05
Dibromochloromethane	2.80E-06	5.56E-07	9.75E-07	8.39E-07
Di-n-butylphthalate	1.03E-05	2.04E-06	3.57E-06	3.08E-06
Diethylphthalate	9.09E-06	1.80E-06	3.16E-06	2.72E-06
Dimethylphthalate	3.45E-06	6.83E-07	1.20E-06	1.03E-06
Dioxins/Furans (EPA TEFs)	1.45E-12	2.87E-13	5.03E-13	4.33E-13
Heptachlor epoxide	9.76E-08	1.93E-08	3.39E-08	2.92E-08
Methyl Chloride	4.95E-05	9.81E-06	1.72E-05	1.48E-05
Methylene Chloride	7.72E-06	1.53E-06	2.68E-06	2.31E-06
Styrene	3.72E-05	7.38E-06	1.29E-05	1.11E-05
Toluene	9.16E-06	1.82E-06	3.18E-06	2.74E-06
Xylene	3.79E-06	7.52E-07	1.32E-06	1.13E-06
INORGANICS				
Aluminum	1.31E-04	2.60E-05	4.56E-05	3.93E-05
Antimony	7.23E-06	1.43E-06	2.51E-06	2.16E-06
Arsenic	2.60E-05	5.16E-06	9.05E-06	7.79E-06
Barium	5.19E-05	1.03E-05	1.81E-05	1.55E-05
Boron	2.42E-04	4.80E-05	8.42E-05	7.24E-05
Cadmium	1.33E-06	2.64E-07	4.62E-07	3.98E-07
Calcium	1.30E-03	2.58E-04	4.51E-04	3.89E-04
Chromium III	2.50E-06	4.95E-07	8.67E-07	7.47E-07
Chromium VI	5.48E-07	1.09E-07	1.90E-07	1.64E-07
Copper	2.68E-03	5.31E-04	9.31E-04	8.01E-04
Iron	5.93E-05	1.18E-05	2.06E-05	1.77E-05
Lead	3.86E-05	7.66E-06	1.34E-05	1.15E-05
Manganese	1.18E-05	2.33E-06	4.09E-06	3.52E-06
Mercury	9.30E-05	1.84E-05	3.23E-05	2.78E-05
Molybdenum	2.60E-05	5.16E-06	9.05E-06	7.79E-06
Nickel	1.04E-05	2.06E-06	3.61E-06	3.11E-06
Silver	2.58E-06	5.12E-07	8.98E-07	7.73E-07
Tin	1.75E-05	3.47E-06	6.08E-06	5.23E-06
Titanium	2.60E-05	5.16E-06	9.05E-06	7.79E-06
Vanadium	1.30E-05	2.58E-06	4.51E-06	3.89E-06
Zinc	6.70E-04	1.33E-04	2.33E-04	2.01E-04
CRITERIA POLLUTANTS/ ACID GASES				
Hydrogen Chloride	1.37E-02	2.71E-03	4.76E-03	4.09E-03
Particulate Matter	8.92E-02	1.77E-02	3.10E-02	2.67E-02
Carbon Monoxide	7.72E-02	1.53E-02	2.68E-02	2.31E-02
Hydrogen Fluoride	3.86E-04	7.66E-05	1.34E-04	1.16E-04
Nitric Acid	3.86E-04	7.66E-05	1.34E-04	1.16E-04
Nitrogen Oxide	3.26E-01	6.47E-02	1.13E-01	9.77E-02
Sulfur Dioxide	1.93E-01	3.83E-02	6.71E-02	5.78E-02

Table 8-4

Average Total Pollutant Daily Intake for the Adult, Resident-A Scenario

Pollutant	Daily intake (mg/kg-day)							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total
ORGANICS								
Benzene	1.24E-09	NA	NA	NA	NA	NA	NA	1.24E-09
Benzoic Acid	5.15E-09	1.83E-10	9.09E-15	3.56E-15	3.14E-12	4.18E-13	1.15E-12	5.34E-09
Bis(2-ethylhexyl)phthalate	1.96E-09	2.16E-07	7.43E-10	8.50E-11	1.19E-12	6.59E-14	4.38E-13	2.18E-07
Bromodichloromethane	4.31E-09	NA	NA	NA	NA	NA	NA	4.31E-09
Butylbenzylphthalate	1.37E-09	2.60E-08	1.88E-13	5.13E-14	8.37E-13	2.76E-13	3.08E-13	2.74E-08
Carbon Tetrachloride	1.13E-09	NA	NA	NA	NA	NA	NA	1.13E-09
Chlorobenzene	1.10E-09	NA	NA	NA	NA	NA	NA	1.10E-09
Chloroform	1.97E-08	NA	NA	NA	NA	NA	NA	1.97E-08
Dibromochloromethane	8.01E-10	4.69E-11	2.03E-15	7.91E-16	4.88E-13	1.08E-13	1.79E-13	8.49E-10
Di-n-butylphthalate	2.94E-09	1.84E-11	2.99E-13	8.68E-14	1.79E-12	NA	6.58E-13	2.96E-09
Diethylphthalate	2.60E-09	1.20E-10	8.47E-15	3.30E-15	1.58E-12	NA	5.82E-13	2.72E-09
Dimethylphthalate	9.85E-10	9.26E-11	2.42E-15	9.45E-16	6.00E-13	NA	2.21E-13	1.08E-09
Dioxins/Furans (EPA TEFs)	4.13E-16	6.25E-19	7.18E-20	6.12E-20	2.52E-19	6.19E-19	9.25E-20	4.15E-16
Heptachlor epoxide	2.79E-11	8.09E-12	2.14E-15	6.56E-16	1.70E-14	1.24E-13	6.24E-15	3.61E-11
Methyl Chloride	1.41E-08	NA	NA	NA	NA	NA	NA	1.41E-08
Methylene Chloride	2.21E-09	NA	NA	NA	NA	NA	NA	2.21E-09
Styrene	1.06E-08	NA	NA	NA	NA	NA	NA	1.06E-08
Toluene	2.62E-09	NA	NA	NA	NA	NA	NA	2.62E-09
Xylene	1.08E-09	NA	NA	NA	NA	NA	NA	1.08E-09
INORGANICS								
Aluminum	3.75E-08	NA	NA	NA	NA	NE	NA	3.75E-08
Antimony	2.07E-09	2.58E-12	6.93E-15	7.63E-15	1.26E-12	NA	4.63E-14	2.07E-09
Arsenic	7.44E-09	6.39E-12	3.99E-12	5.23E-14	4.53E-12	8.57E-13	1.67E-13	7.46E-09
Barium	1.48E-08	NA	NA	NA	NA	NA	NA	1.48E-08
Boron	6.92E-08	NA	NA	NA	NA	NE	NA	6.92E-08
Cadmium	3.80E-10	8.61E-13	7.26E-14	3.17E-15	2.31E-13	NA	8.51E-15	3.81E-10
Calcium	3.71E-07	NA	NA	NA	NA	NE	NA	3.71E-07
Chromium III	7.13E-10	NA	NA	NA	NA	NA	NA	7.13E-10
Chromium VI	1.56E-10	NA	NA	NA	NA	NA	NA	1.56E-10
Copper	7.65E-07	2.68E-09	2.40E-10	1.65E-10	4.66E-10	2.82E-10	1.71E-11	7.69E-07
Iron	1.69E-08	NA	NA	NA	NA	NA	NA	1.69E-08
Lead	1.10E-08	NA	NA	NA	NA	NA	NA	1.10E-08

Table 8-4
(Continued)

Pollutant	Daily intake (mg/kg-day)							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total
Manganese	3.36E-09	NA	NA	NA	NA	NA	NA	3.36E-09
Mercury	2.66E-08	9.46E-11	2.00E-12	1.50E-10	1.62E-11	NA	5.95E-13	2.68E-08
Molybdenum	7.44E-09	NA	NA	NA	NA	NE	NA	7.44E-09
Nickel	2.97E-09	NA	NA	NA	NA	NA	NA	2.97E-09
Silver	7.38E-10	NA	NA	NA	NA	NA	NA	7.38E-10
Tin	4.99E-09	NA	NA	NA	NA	NE	NA	4.99E-09
Titanium	7.44E-09	NA	NA	NA	NA	NE	NA	7.44E-09
Vanadium	3.71E-09	NA	NA	NA	NA	1.13E-14	NA	3.71E-09
Zinc	1.92E-07	NA	NA	NA	NA	3.46E-11	NA	1.92E-07
CRITERIA POLLUTANTS/ ACID GASES								
Hydrogen Chloride	3.91E-06	NA	NA	NA	NA	NA	NA	3.91E-06
Particulate Matter	2.55E-05	NA	NA	NA	NA	NA	NA	2.55E-05
Carbon Monoxide	2.21E-05	NA	NA	NA	NA	NA	NA	2.21E-05
Hydrogen Fluoride	1.10E-07	NA	NA	NA	NA	NA	NA	1.10E-07
Nitric Acid	1.10E-07	NA	NA	NA	NA	NA	NA	1.10E-07
Nitrogen Oxide	9.33E-05	NA	NA	NA	NA	NA	NA	9.33E-05
Sulfur Dioxide	5.52E-05	NA	NA	NA	NA	NA	NA	5.52E-05

Table 8-5

Maximum Total Pollutant Daily Intake for the Adult, Resident-A Scenario

Pollutant	Daily intake (mg/kg-day)							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total
ORGANICS								
Benzene	1.24E-09	NA	NA	NA	NA	NA	NA	1.24E-09
Benzoic Acid	5.15E-09	3.19E-10	1.04E-14	3.74E-15	3.18E-12	4.18E-13	1.17E-12	5.48E-09
Bis(2-ethylhexyl)phthalate	1.96E-09	2.19E-07	2.58E-08	2.89E-09	1.21E-12	6.59E-14	4.44E-13	2.50E-07
Bromodichloromethane	4.31E-09	NA	NA	NA	NA	NA	NA	4.31E-09
Butylbenzylphthalate	1.37E-09	2.64E-08	2.92E-12	3.57E-13	8.49E-13	2.76E-13	3.12E-13	2.78E-08
Carbon Tetrachloride	1.13E-09	NA	NA	NA	NA	NA	NA	1.13E-09
Chlorobenzene	1.10E-09	NA	NA	NA	NA	NA	NA	1.10E-09
Chloroform	1.97E-08	NA	NA	NA	NA	NA	NA	1.97E-08
Dibromochloromethane	8.01E-10	6.83E-11	2.49E-15	8.52E-16	4.95E-13	1.08E-13	1.82E-13	8.70E-10
Di-n-butylphthalate	2.94E-09	9.46E-11	3.98E-12	5.00E-13	1.82E-12	NA	6.68E-13	3.04E-09
Diethylphthalate	2.60E-09	1.88E-10	1.12E-14	3.64E-15	1.60E-12	NA	5.90E-13	2.79E-09
Dimethylphthalate	9.85E-10	1.19E-10	2.96E-15	1.01E-15	6.08E-13	NA	2.24E-13	1.11E-09
Dioxins/Furans (EPA TEFs)	4.13E-16	1.13E-17	1.36E-18	5.62E-19	2.55E-19	6.19E-19	9.39E-20	4.27E-16
Heptachlor epoxide	2.79E-11	8.93E-12	2.42E-14	3.13E-15	1.72E-14	1.24E-13	6.34E-15	3.70E-11
Methyl Chloride	1.41E-08	NA	NA	NA	NA	NA	NA	1.41E-08
Methylene Chloride	2.21E-09	NA	NA	NA	NA	NA	NA	2.21E-09
Styrene	1.06E-08	NA	NA	NA	NA	NA	NA	1.06E-08
Toluene	2.62E-09	NA	NA	NA	NA	NA	NA	2.62E-09
Xylene	1.08E-09	NA	NA	NA	NA	NA	NA	1.08E-09
INORGANICS								
Aluminum	3.75E-08	NA	NA	NA	NA	NE	NA	3.75E-08
Antimony	2.07E-09	5.60E-11	8.69E-14	3.67E-14	1.28E-12	NA	4.69E-14	2.12E-09
Arsenic	7.44E-09	1.99E-10	2.13E-11	2.62E-13	4.60E-12	8.57E-13	1.69E-13	7.67E-09
Barium	1.48E-08	NA	NA	NA	NA	NA	NA	1.48E-08
Boron	6.92E-08	NA	NA	NA	NA	NE	NA	6.92E-08
Cadmium	3.80E-10	1.07E-11	2.21E-13	6.15E-15	2.35E-13	NA	8.64E-15	3.91E-10
Calcium	3.71E-07	NA	NA	NA	NA	NE	NA	3.71E-07
Chromium III	7.13E-10	NA	NA	NA	NA	NA	NA	7.13E-10
Chromium VI	1.56E-10	NA	NA	NA	NA	NA	NA	1.56E-10
Copper	7.65E-07	2.25E-08	6.87E-10	2.75E-10	4.73E-10	2.82E-10	1.74E-11	7.89E-07
Iron	1.69E-08	NA	NA	NA	NA	NA	NA	1.69E-08
Lead	1.10E-08	NA	NA	NA	NA	NA	NA	1.10E-08

Table 8-5
(Continued)

Pollutant	Daily intake (mg/kg-day)							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total
Manganese	3.36E-09	NA	NA	NA	NA	NA	NA	3.36E-09
Mercury	2.66E-08	7.83E-10	6.65E-12	2.45E-10	1.64E-11	NA	6.04E-13	2.76E-08
Molybdenum	7.44E-09	NA	NA	NA	NA	NE	NA	7.44E-09
Nickel	2.97E-09	NA	NA	NA	NA	NA	NA	2.97E-09
Silver	7.38E-10	NA	NA	NA	NA	NA	NA	7.38E-10
Tin	4.99E-09	NA	NA	NA	NA	NE	NA	4.99E-09
Titanium	7.44E-09	NA	NA	NA	NA	NE	NA	7.44E-09
Vanadium	3.71E-09	NA	NA	NA	NA	1.13E-14	NA	3.71E-09
Zinc	1.92E-07	NA	NA	NA	NA	3.46E-11	NA	1.92E-07
CRITERIA POLLUTANTS/ ACID GASES								
Hydrogen Chloride	3.91E-06	NA	NA	NA	NA	NA	NA	3.91E-06
Particulate Matter	2.55E-05	NA	NA	NA	NA	NA	NA	2.55E-05
Carbon Monoxide	2.21E-05	NA	NA	NA	NA	NA	NA	2.21E-05
Hydrogen Fluoride	1.10E-07	NA	NA	NA	NA	NA	NA	1.10E-07
Nitric Acid	1.10E-07	NA	NA	NA	NA	NA	NA	1.10E-07
Nitrogen Oxide	9.33E-05	NA	NA	NA	NA	NA	NA	9.33E-05
Sulfur Dioxide	5.52E-05	NA	NA	NA	NA	NA	NA	5.52E-05

Table 8-6

Average Total Pollutant Daily Intake for the Adult, Resident-B Scenario

Pollutant	Daily intake (mg/kg-day)							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total
ORGANICS								
Benzene	2.47E-10	NA	NA	NA	NA	NA	NA	2.47E-10
Benzoic Acid	1.02E-09	2.92E-10	9.09E-15	3.56E-15	5.10E-12	4.18E-13	1.88E-12	1.32E-09
Bis(2-ethylhexyl)phthalate	3.88E-10	3.50E-07	7.43E-10	8.50E-11	1.93E-12	6.59E-14	7.12E-13	3.52E-07
Bromodichloromethane	8.55E-10	NA	NA	NA	NA	NA	NA	8.55E-10
Butylbenzylphthalate	2.72E-10	4.22E-08	1.88E-13	5.13E-14	1.36E-12	2.76E-13	5.00E-13	4.25E-08
Carbon Tetrachloride	2.25E-10	NA	NA	NA	NA	NA	NA	2.25E-10
Chlorobenzene	2.19E-10	NA	NA	NA	NA	NA	NA	2.19E-10
Chloroform	3.90E-09	NA	NA	NA	NA	NA	NA	3.90E-09
Dibromochloromethane	1.59E-10	7.53E-11	2.03E-15	7.91E-16	7.93E-13	1.08E-13	2.92E-13	2.35E-10
Di-n-butylphthalate	5.83E-10	2.67E-11	2.99E-13	8.68E-14	2.91E-12	NA	1.07E-12	6.14E-10
Diethylphthalate	5.15E-10	1.91E-10	8.47E-15	3.30E-15	2.57E-12	NA	9.45E-13	7.10E-10
Dimethylphthalate	1.95E-10	1.49E-10	2.42E-15	9.45E-16	9.74E-13	NA	3.58E-13	3.46E-10
Dioxins/Furans (EPA TEFs)	8.19E-17	5.59E-19	7.18E-20	6.12E-20	4.09E-19	6.19E-19	1.50E-19	8.38E-17
Heptachlor epoxide	5.53E-12	1.31E-11	2.14E-15	6.56E-16	2.76E-14	1.24E-13	1.01E-14	1.88E-11
Methyl Chloride	2.80E-09	NA	NA	NA	NA	NA	NA	2.80E-09
Methylene Chloride	4.37E-10	NA	NA	NA	NA	NA	NA	4.37E-10
Styrene	2.11E-09	NA	NA	NA	NA	NA	NA	2.11E-09
Toluene	5.19E-10	NA	NA	NA	NA	NA	NA	5.19E-10
Xylene	2.15E-10	NA	NA	NA	NA	NA	NA	2.15E-10
INORGANICS								
Aluminum	7.44E-09	NA	NA	NA	NA	NE	NA	7.44E-09
Antimony	4.10E-10	1.91E-12	6.93E-15	7.63E-15	2.04E-12	NA	7.52E-14	4.14E-10
Arsenic	1.48E-09	2.16E-12	3.99E-12	5.23E-14	7.36E-12	8.57E-13	2.71E-13	1.49E-09
Barium	2.94E-09	NA	NA	NA	NA	NA	NA	2.94E-09
Boron	1.37E-08	NA	NA	NA	NA	NE	NA	1.37E-08
Cadmium	7.54E-11	9.79E-13	7.26E-14	3.17E-15	3.76E-13	NA	1.38E-14	7.68E-11
Calcium	7.36E-08	NA	NA	NA	NA	NE	NA	7.36E-08
Chromium III	1.41E-10	NA	NA	NA	NA	NA	NA	1.41E-10
Chromium VI	3.10E-11	NA	NA	NA	NA	NA	NA	3.10E-11
Copper	1.52E-07	3.50E-09	2.40E-10	1.65E-10	7.57E-10	2.82E-10	2.78E-11	1.57E-07
Iron	3.36E-09	NA	NA	NA	NA	NA	NA	3.36E-09
Lead	2.19E-09	NA	NA	NA	NA	NA	NA	2.19E-09

Table 8-6
(Continued)

Pollutant	Daily intake (mg/kg-day)							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total
Manganese	6.66E-10	NA	NA	NA	NA	NA	NA	6.66E-10
Mercury	5.27E-09	1.24E-10	2.00E-12	1.50E-10	2.63E-11	NA	9.67E-13	5.57E-09
Molybdenum	1.48E-09	NA	NA	NA	NA	NE	NA	1.48E-09
Nickel	5.89E-10	NA	NA	NA	NA	NA	NA	5.89E-10
Silver	1.46E-10	NA	NA	NA	NA	NA	NA	1.46E-10
Tin	9.90E-10	NA	NA	NA	NA	NE	NA	9.90E-10
Titanium	1.48E-09	NA	NA	NA	NA	NE	NA	1.48E-09
Vanadium	7.36E-10	NA	NA	NA	NA	1.13E-14	NA	7.36E-10
Zinc	3.80E-08	NA	NA	NA	NA	3.46E-11	NA	3.80E-08
CRITERIA POLLUTANTS/ ACID GASES								
Hydrogen Chloride	7.76E-07	NA	NA	NA	NA	NA	NA	7.76E-07
Particulate Matter	5.05E-06	NA	NA	NA	NA	NA	NA	5.05E-06
Carbon Monoxide	4.37E-06	NA	NA	NA	NA	NA	NA	4.37E-06
Hydrogen Fluoride	2.19E-08	NA	NA	NA	NA	NA	NA	2.19E-08
Nitric Acid	2.19E-08	NA	NA	NA	NA	NA	NA	2.19E-08
Nitrogen Oxide	1.85E-05	NA	NA	NA	NA	NA	NA	1.85E-05
Sulfur Dioxide	1.09E-05	NA	NA	NA	NA	NA	NA	1.09E-05

Table 8-7

Maximum Total Pollutant Daily Intake for the Adult, Resident-B Scenario

Pollutant	Daily intake (mg/kg-day)							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total
ORGANICS								
Benzene	2.47E-10	NA	NA	NA	NA	NA	NA	2.47E-10
Benzoic Acid	1.02E-09	3.19E-10	1.04E-14	3.74E-15	5.17E-12	4.18E-13	1.90E-12	1.35E-09
Bis(2-ethylhexyl)phthalate	3.88E-10	3.56E-07	2.58E-08	2.89E-09	1.96E-12	6.59E-14	7.22E-13	3.85E-07
Bromodichloromethane	8.55E-10	NA	NA	NA	NA	NA	NA	8.55E-10
Butylbenzylphthalate	2.72E-10	4.28E-08	2.92E-12	3.57E-13	1.38E-12	2.76E-13	5.07E-13	4.31E-08
Carbon Tetrachloride	2.25E-10	NA	NA	NA	NA	NA	NA	2.25E-10
Chlorobenzene	2.19E-10	NA	NA	NA	NA	NA	NA	2.19E-10
Chloroform	3.90E-09	NA	NA	NA	NA	NA	NA	3.90E-09
Dibromochloromethane	1.59E-10	8.00E-11	2.49E-15	8.52E-16	8.04E-13	1.08E-13	2.96E-13	2.40E-10
Di-n-butylphthalate	5.83E-10	4.03E-11	3.98E-12	5.00E-13	2.95E-12	NA	1.08E-12	6.31E-10
Diethylphthalate	5.15E-10	2.06E-10	1.12E-14	3.64E-15	2.61E-12	NA	9.59E-13	7.24E-10
Dimethylphthalate	1.95E-10	1.56E-10	2.96E-15	1.01E-15	9.88E-13	NA	3.64E-13	3.53E-10
Dioxins/Furans (EPA TEFs)	8.19E-17	2.42E-18	1.36E-18	5.62E-19	4.15E-19	6.19E-19	1.53E-19	8.75E-17
Heptachlor epoxide	5.53E-12	1.34E-11	2.42E-14	3.13E-15	2.80E-14	1.24E-13	1.03E-14	1.91E-11
Methyl Chloride	2.80E-09	NA	NA	NA	NA	NA	NA	2.80E-09
Methylene Chloride	4.37E-10	NA	NA	NA	NA	NA	NA	4.37E-10
Styrene	2.11E-09	NA	NA	NA	NA	NA	NA	2.11E-09
Toluene	5.19E-10	NA	NA	NA	NA	NA	NA	5.19E-10
Xylene	2.15E-10	NA	NA	NA	NA	NA	NA	2.15E-10
INORGANICS								
Aluminum	7.44E-09	NA	NA	NA	NA	NE	NA	7.44E-09
Antimony	4.10E-10	1.12E-11	8.69E-14	3.67E-14	2.07E-12	NA	7.63E-14	4.23E-10
Arsenic	1.48E-09	3.56E-11	2.13E-11	2.62E-13	7.47E-12	8.57E-13	2.75E-13	1.54E-09
Barium	2.94E-09	NA	NA	NA	NA	NA	NA	2.94E-09
Boron	1.37E-08	NA	NA	NA	NA	NE	NA	1.37E-08
Cadmium	7.54E-11	2.70E-12	2.21E-13	6.15E-15	3.81E-13	NA	1.40E-14	7.87E-11
Calcium	7.36E-08	NA	NA	NA	NA	NE	NA	7.36E-08
Chromium III	1.41E-10	NA	NA	NA	NA	NA	NA	1.41E-10
Chromium VI	3.10E-11	NA	NA	NA	NA	NA	NA	3.10E-11
Copper	1.52E-07	6.98E-09	6.87E-10	2.75E-10	7.68E-10	2.82E-10	2.82E-11	1.61E-07
Iron	3.36E-09	NA	NA	NA	NA	NA	NA	3.36E-09
Lead	2.19E-09	NA	NA	NA	NA	NA	NA	2.19E-09

Table 8-7
(Continued)

Pollutant	Daily intake (mg/kg-day)							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total
Manganese	6.66E-10	NA	NA	NA	NA	NA	NA	6.66E-10
Mercury	5.27E-09	2.45E-10	6.65E-12	2.45E-10	2.67E-11	NA	9.81E-13	5.79E-09
Molybdenum	1.48E-09	NA	NA	NA	NA	NE	NA	1.48E-09
Nickel	5.89E-10	NA	NA	NA	NA	NA	NA	5.89E-10
Silver	1.46E-10	NA	NA	NA	NA	NA	NA	1.46E-10
Tin	9.90E-10	NA	NA	NA	NA	NE	NA	9.90E-10
Titanium	1.48E-09	NA	NA	NA	NA	NE	NA	1.48E-09
Vanadium	7.36E-10	NA	NA	NA	NA	1.13E-14	NA	7.36E-10
Zinc	3.80E-08	NA	NA	NA	NA	3.46E-11	NA	3.80E-08
CRITERIA POLLUTANTS/ ACID GASES								
Hydrogen Chloride	7.76E-07	NA	NA	NA	NA	NA	NA	7.76E-07
Particulate Matter	5.05E-06	NA	NA	NA	NA	NA	NA	5.05E-06
Carbon Monoxide	4.37E-06	NA	NA	NA	NA	NA	NA	4.37E-06
Hydrogen Fluoride	2.19E-08	NA	NA	NA	NA	NA	NA	2.19E-08
Nitric Acid	2.19E-08	NA	NA	NA	NA	NA	NA	2.19E-08
Nitrogen Oxide	1.85E-05	NA	NA	NA	NA	NA	NA	1.85E-05
Sulfur Dioxide	1.09E-05	NA	NA	NA	NA	NA	NA	1.09E-05

Table 8-8

Average Total Pollutant Daily Intake for the Adult, Farmer Scenario

Pollutant	Daily intake (mg/kg-day)							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total
ORGANICS								
Benzene	4.32E-10	NA	NA	NA	NA	NA	NA	4.32E-10
Benzoic Acid	1.79E-09	6.17E-10	1.82E-13	7.11E-14	3.05E-12	4.18E-13	5.50E-12	2.42E-09
Bis(2-ethylhexyl)phthalate	6.80E-10	1.81E-06	1.49E-08	1.70E-09	1.16E-12	6.59E-14	2.08E-12	1.83E-06
Bromodichloromethane	1.50E-09	NA	NA	NA	NA	NA	NA	1.50E-09
Butylbenzylphthalate	4.78E-10	2.18E-07	3.76E-12	1.03E-12	8.12E-13	2.76E-13	1.46E-12	2.19E-07
Carbon Tetrachloride	3.94E-10	NA	NA	NA	NA	NA	NA	3.94E-10
Chlorobenzene	3.83E-10	NA	NA	NA	NA	NA	NA	3.83E-10
Chloroform	6.83E-09	NA	NA	NA	NA	NA	NA	6.83E-09
Dibromochloromethane	2.79E-10	3.05E-10	4.05E-14	1.58E-14	4.74E-13	1.08E-13	8.54E-13	5.85E-10
Di-n-butylphthalate	1.02E-09	1.34E-10	5.97E-12	1.74E-12	1.74E-12	NA	3.13E-12	1.17E-09
Diethylphthalate	9.03E-10	7.96E-10	1.69E-13	6.60E-14	1.54E-12	NA	2.77E-12	1.70E-09
Dimethylphthalate	3.42E-10	6.65E-10	4.84E-14	1.89E-14	5.82E-13	NA	1.05E-12	1.01E-09
Dioxins/Furans (EPA TEFs)	1.44E-16	2.53E-18	1.44E-18	1.22E-18	2.44E-19	6.19E-19	4.40E-19	1.50E-16
Heptachlor epoxide	9.69E-12	6.78E-11	4.27E-14	1.31E-14	1.65E-14	1.24E-13	2.97E-14	7.77E-11
Methyl Chloride	4.91E-09	NA	NA	NA	NA	NA	NA	4.91E-09
Methylene Chloride	7.67E-10	NA	NA	NA	NA	NA	NA	7.67E-10
Styrene	3.69E-09	NA	NA	NA	NA	NA	NA	3.69E-09
Toluene	9.10E-10	NA	NA	NA	NA	NA	NA	9.10E-10
Xylene	3.76E-10	NA	NA	NA	NA	NA	NA	3.76E-10
INORGANICS								
Aluminum	1.30E-08	NA	NA	NA	NA	NE	NA	1.30E-08
Antimony	7.18E-10	3.42E-12	1.39E-13	1.53E-13	1.22E-12	NA	2.20E-13	7.23E-10
Arsenic	2.59E-09	4.87E-12	7.98E-11	1.05E-12	4.40E-12	8.57E-13	7.93E-13	2.68E-09
Barium	5.16E-09	NA	NA	NA	NA	NA	NA	5.16E-09
Boron	2.41E-08	NA	NA	NA	NA	NE	NA	2.41E-08
Cadmium	1.32E-10	1.99E-12	1.45E-12	6.35E-14	2.25E-13	NA	4.05E-14	1.36E-10
Calcium	1.29E-07	NA	NA	NA	NA	NE	NA	1.29E-07
Chromium III	2.48E-10	NA	NA	NA	NA	NA	NA	2.48E-10
Chromium VI	5.44E-11	NA	NA	NA	NA	NA	NA	5.44E-11
Copper	2.66E-07	6.74E-09	4.79E-09	3.31E-09	4.52E-10	2.82E-10	8.16E-11	2.82E-07
Iron	5.89E-09	NA	NA	NA	NA	NA	NA	5.89E-09
Lead	3.83E-09	NA	NA	NA	NA	NA	NA	3.83E-09

Table 8-8
(Continued)

Pollutant	Daily intake (mg/kg-day)							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total
Manganese	1.17E-09	NA	NA	NA	NA	NA	NA	1.17E-09
Mercury	9.24E-09	2.14E-10	4.00E-11	3.00E-09	1.57E-11	NA	2.83E-12	1.25E-08
Molybdenum	2.59E-09	NA	NA	NA	NA	NE	NA	2.59E-09
Nickel	1.03E-09	NA	NA	NA	NA	NA	NA	1.03E-09
Silver	2.57E-10	NA	NA	NA	NA	NA	NA	2.57E-10
Tin	1.74E-09	NA	NA	NA	NA	NE	NA	1.74E-09
Titanium	2.59E-09	NA	NA	NA	NA	NE	NA	2.59E-09
Vanadium	1.29E-09	NA	NA	NA	NA	1.13E-14	NA	1.29E-09
Zinc	6.66E-08	NA	NA	NA	NA	3.46E-11	NA	6.66E-08
CRITERIA POLLUTANTS/ ACID GASES								
Hydrogen Chloride	1.36E-06	NA	NA	NA	NA	NA	NA	1.36E-06
Particulate Matter	8.85E-06	NA	NA	NA	NA	NA	NA	8.85E-06
Carbon Monoxide	7.67E-06	NA	NA	NA	NA	NA	NA	7.67E-06
Hydrogen Fluoride	3.83E-08	NA	NA	NA	NA	NA	NA	3.83E-08
Nitric Acid	3.83E-08	NA	NA	NA	NA	NA	NA	3.83E-08
Nitrogen Oxide	3.24E-05	NA	NA	NA	NA	NA	NA	3.24E-05
Sulfur Dioxide	1.92E-05	NA	NA	NA	NA	NA	NA	1.92E-05

Table 8-9

Maximum Total Pollutant Daily Intake for the Adult, Farmer Scenario

Pollutant	Daily intake (mg/kg-day)							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total
ORGANICS								
Benzene	4.32E-10	NA	NA	NA	NA	NA	NA	4.32E-10
Benzoic Acid	1.79E-09	6.97E-10	2.09E-13	7.48E-14	3.09E-12	4.18E-13	5.57E-12	2.50E-09
Bis(2-ethylhexyl)phthalate	6.80E-10	1.84E-06	5.16E-07	5.78E-08	1.17E-12	6.59E-14	2.11E-12	2.41E-06
Bromodichloromethane	1.50E-09	NA	NA	NA	NA	NA	NA	1.50E-09
Butylbenzylphthalate	4.78E-10	2.22E-07	5.83E-11	7.15E-12	8.24E-13	2.76E-13	1.49E-12	2.22E-07
Carbon Tetrachloride	3.94E-10	NA	NA	NA	NA	NA	NA	3.94E-10
Chlorobenzene	3.83E-10	NA	NA	NA	NA	NA	NA	3.83E-10
Chloroform	6.83E-09	NA	NA	NA	NA	NA	NA	6.83E-09
Dibromochloromethane	2.79E-10	3.20E-10	4.99E-14	1.70E-14	4.81E-13	1.08E-13	8.67E-13	6.00E-10
Di-n-butylphthalate	1.02E-09	1.76E-10	7.96E-11	1.00E-11	1.76E-12	NA	3.18E-12	1.29E-09
Diethylphthalate	9.03E-10	8.43E-10	2.23E-13	7.27E-14	1.56E-12	NA	2.81E-12	1.75E-09
Dimethylphthalate	3.42E-10	6.88E-10	5.91E-14	2.03E-14	5.91E-13	NA	1.07E-12	1.03E-09
Dioxins/Furans (EPA TEFs)	1.44E-16	8.26E-18	2.71E-17	1.12E-17	2.48E-19	6.19E-19	4.47E-19	1.92E-16
Heptachlor epoxide	9.69E-12	6.92E-11	4.84E-13	6.26E-14	1.67E-14	1.24E-13	3.02E-14	7.96E-11
Methyl Chloride	4.91E-09	NA	NA	NA	NA	NA	NA	4.91E-09
Methylene Chloride	7.67E-10	NA	NA	NA	NA	NA	NA	7.67E-10
Styrene	3.69E-09	NA	NA	NA	NA	NA	NA	3.69E-09
Toluene	9.10E-10	NA	NA	NA	NA	NA	NA	9.10E-10
Xylene	3.76E-10	NA	NA	NA	NA	NA	NA	3.76E-10
INORGANICS								
Aluminum	1.30E-08	NA	NA	NA	NA	NE	NA	1.30E-08
Antimony	7.18E-10	3.19E-11	1.74E-12	7.34E-13	1.24E-12	NA	2.23E-13	7.54E-10
Arsenic	2.59E-09	1.07E-10	4.26E-10	5.23E-12	4.46E-12	8.57E-13	8.05E-13	3.13E-09
Barium	5.16E-09	NA	NA	NA	NA	NA	NA	5.16E-09
Boron	2.41E-08	NA	NA	NA	NA	NE	NA	2.41E-08
Cadmium	1.32E-10	7.26E-12	4.41E-12	1.23E-13	2.28E-13	NA	4.11E-14	1.44E-10
Calcium	1.29E-07	NA	NA	NA	NA	NE	NA	1.29E-07
Chromium III	2.48E-10	NA	NA	NA	NA	NA	NA	2.48E-10
Chromium VI	5.44E-11	NA	NA	NA	NA	NA	NA	5.44E-11
Copper	2.66E-07	1.74E-08	1.37E-08	5.50E-09	4.59E-10	2.82E-10	8.28E-11	3.03E-07
Iron	5.89E-09	NA	NA	NA	NA	NA	NA	5.89E-09
Lead	3.83E-09	NA	NA	NA	NA	NA	NA	3.83E-09

Table 8-9
(Continued)

Pollutant	Daily intake (mg/kg-day)							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total
Manganese	1.17E-09	NA	NA	NA	NA	NA	NA	1.17E-09
Mercury	9.24E-09	5.83E-10	1.33E-10	4.91E-09	1.59E-11	NA	2.87E-12	1.49E-08
Molybdenum	2.59E-09	NA	NA	NA	NA	NE	NA	2.59E-09
Nickel	1.03E-09	NA	NA	NA	NA	NA	NA	1.03E-09
Silver	2.57E-10	NA	NA	NA	NA	NA	NA	2.57E-10
Tin	1.74E-09	NA	NA	NA	NA	NE	NA	1.74E-09
Titanium	2.59E-09	NA	NA	NA	NA	NE	NA	2.59E-09
Vanadium	1.29E-09	NA	NA	NA	NA	1.13E-14	NA	1.29E-09
Zinc	6.66E-08	NA	NA	NA	NA	3.46E-11	NA	6.66E-08
CRITERIA POLLUTANTS/ ACID GASES								
Hydrogen Chloride	1.36E-06	NA	NA	NA	NA	NA	NA	1.36E-06
Particulate Matter	8.85E-06	NA	NA	NA	NA	NA	NA	8.85E-06
Carbon Monoxide	7.67E-06	NA	NA	NA	NA	NA	NA	7.67E-06
Hydrogen Fluoride	3.83E-08	NA	NA	NA	NA	NA	NA	3.83E-08
Nitric Acid	3.83E-08	NA	NA	NA	NA	NA	NA	3.83E-08
Nitrogen Oxide	3.24E-05	NA	NA	NA	NA	NA	NA	3.24E-05
Sulfur Dioxide	1.92E-05	NA	NA	NA	NA	NA	NA	1.92E-05

Table 8-10

Average Total Pollutant Daily Intake for the Adult, Worker Scenario

Pollutant	Daily Intake (mg/kg-day) Inhalation	Soil/Dust Ingestion	Dermal Absorption	Total
ORGANICS	8-10			
Benzene	1.27E-10	NA	NA	1.27E-10
Benzoic Acid	5.28E-10	2.79E-12	5.81E-12	5.37E-10
Bis(2-ethylhexyl)phthalate	2.00E-10	1.06E-12	2.20E-12	2.04E-10
Bromodichloromethane	4.42E-10	NA	NA	4.42E-10
Butylbenzylphthalate	1.41E-10	7.44E-13	1.55E-12	1.43E-10
Carbon Tetrachloride	1.16E-10	NA	NA	1.16E-10
Chlorobenzene	1.13E-10	NA	NA	1.13E-10
Chloroform	2.01E-09	NA	NA	2.01E-09
Dibromochloromethane	8.21E-11	4.34E-13	9.03E-13	8.34E-11
Di-n-butylphthalate	3.01E-10	1.59E-12	3.31E-12	3.06E-10
Diethylphthalate	2.66E-10	1.41E-12	2.93E-12	2.70E-10
Dimethylphthalate	1.01E-10	5.34E-13	1.11E-12	1.03E-10
Dioxins/Furans (EPA TEFs)	4.23E-17	2.24E-19	4.66E-19	4.30E-17
Heptachlor epoxide	2.86E-12	1.51E-14	3.14E-14	2.90E-12
Methyl Chloride	1.45E-09	NA	NA	1.45E-09
Methylene Chloride	2.26E-10	NA	NA	2.26E-10
Styrene	1.09E-09	NA	NA	1.09E-09
Toluene	2.68E-10	NA	NA	2.68E-10
Xylene	1.11E-10	NA	NA	1.11E-10
INORGANICS				
Aluminum	3.84E-09	NA	NA	3.84E-09
Antimony	2.12E-10	1.12E-12	2.33E-13	2.13E-10
Arsenic	7.62E-10	4.03E-12	8.39E-13	7.67E-10
Barium	1.52E-09	NA	NA	1.52E-09
Boron	7.09E-09	NA	NA	7.09E-09
Cadmium	3.89E-11	2.06E-13	4.28E-14	3.92E-11
Calcium	3.80E-08	NA	NA	3.80E-08
Chromium III	7.30E-11	NA	NA	7.30E-11
Chromium VI	1.60E-11	NA	NA	1.60E-11
Copper	7.84E-08	4.15E-10	8.62E-11	7.89E-08
Iron	1.74E-09	NA	NA	1.74E-09
Lead	1.13E-09	NA	NA	1.13E-09
Manganese	3.44E-10	NA	NA	3.44E-10
Mercury	2.72E-09	1.44E-11	3.00E-12	2.74E-09
Molybdenum	7.62E-10	NA	NA	7.62E-10
Nickel	3.04E-10	NA	NA	3.04E-10
Silver	7.56E-11	NA	NA	7.56E-11
Tin	5.12E-10	NA	NA	5.12E-10
Titanium	7.62E-10	NA	NA	7.62E-10
Vanadium	3.80E-10	NA	NA	3.80E-10
Zinc	1.96E-08	NA	NA	1.96E-08
CRITERIA POLLUTANTS/ ACID GASES				
Hydrogen Chloride	4.01E-07	NA	NA	4.01E-07
Particulate Matter	2.61E-06	NA	NA	2.61E-06
Carbon Monoxide	2.26E-06	NA	NA	2.26E-06
Hydrogen Fluoride	1.13E-08	NA	NA	1.13E-08
Nitric Acid	1.13E-08	NA	NA	1.13E-08
Nitrogen Oxide	9.55E-06	NA	NA	9.55E-06
Sulfur Dioxide	5.65E-06	NA	NA	5.65E-06

Table 8-11

Maximum Total Pollutant Daily Intake for the Adult, Worker Scenario

Pollutant	Daily Intake (mg/kg-day) Inhalation	Soil/Dust Ingestion	Dermal Absorption	Total
ORGANICS				
Benzene	1.27E-10	NA	NA	1.27E-10
Benzoic Acid	5.28E-10	2.83E-12	5.89E-12	5.37E-10
Bis(2-ethylhexyl)phthalate	2.00E-10	1.07E-12	2.24E-12	2.04E-10
Bromodichloromethane	4.42E-10	NA	NA	4.42E-10
Butylbenzylphthalate	1.41E-10	7.55E-13	1.57E-12	1.43E-10
Carbon Tetrachloride	1.16E-10	NA	NA	1.16E-10
Chlorobenzene	1.13E-10	NA	NA	1.13E-10
Chloroform	2.01E-09	NA	NA	2.01E-09
Dibromochloromethane	8.21E-11	4.40E-13	9.16E-13	8.34E-11
Di-n-butylphthalate	3.01E-10	1.62E-12	3.36E-12	3.06E-10
Diethylphthalate	2.66E-10	1.43E-12	2.97E-12	2.70E-10
Dimethylphthalate	1.01E-10	5.41E-13	1.13E-12	1.03E-10
Dioxins/Furans (EPA TEFs)	4.23E-17	2.27E-19	4.72E-19	4.30E-17
Heptachlor epoxide	2.86E-12	1.53E-14	3.19E-14	2.90E-12
Methyl Chloride	1.45E-09	NA	NA	1.45E-09
Methylene Chloride	2.26E-10	NA	NA	2.26E-10
Styrene	1.09E-09	NA	NA	1.09E-09
Toluene	2.68E-10	NA	NA	2.68E-10
Xylene	1.11E-10	NA	NA	1.11E-10
INORGANICS				
Aluminum	3.84E-09	NA	NA	3.84E-09
Antimony	2.12E-10	1.14E-12	2.36E-13	2.13E-10
Arsenic	7.62E-10	4.09E-12	8.51E-13	7.67E-10
Barium	1.52E-09	NA	NA	1.52E-09
Boron	7.09E-09	NA	NA	7.09E-09
Cadmium	3.89E-11	2.09E-13	4.35E-14	3.92E-11
Calcium	3.80E-08	NA	NA	3.80E-08
Chromium III	7.30E-11	NA	NA	7.30E-11
Chromium VI	1.60E-11	NA	NA	1.60E-11
Copper	7.84E-08	4.21E-10	8.75E-11	7.89E-08
Iron	1.74E-09	NA	NA	1.74E-09
Lead	1.13E-09	NA	NA	1.13E-09
Manganese	3.44E-10	NA	NA	3.44E-10
Mercury	2.72E-09	1.46E-11	3.04E-12	2.74E-09
Molybdenum	7.62E-10	NA	NA	7.62E-10
Nickel	3.04E-10	NA	NA	3.04E-10
Silver	7.56E-11	NA	NA	7.56E-11
Tin	5.12E-10	NA	NA	5.12E-10
Titanium	7.62E-10	NA	NA	7.62E-10
Vanadium	3.80E-10	NA	NA	3.80E-10
Zinc	1.96E-08	NA	NA	1.96E-08
CRITERIA POLLUTANTS/ ACID GASES				
Hydrogen Chloride	4.01E-07	NA	NA	4.01E-07
Particulate Matter	2.61E-06	NA	NA	2.61E-06
Carbon Monoxide	2.26E-06	NA	NA	2.26E-06
Hydrogen Fluoride	1.13E-08	NA	NA	1.13E-08
Nitric Acid	1.13E-08	NA	NA	1.13E-08
Nitrogen Oxide	9.55E-06	NA	NA	9.55E-06
Sulfur Dioxide	5.65E-06	NA	NA	5.65E-06

Table 8-12

Average Total Pollutant Daily Intake for Child, Resident-A Scenario

Pollutant	Daily intake (mg/kg-day)							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total
ORGANICS								
Benzene	2.81E-09	NA	NA	NA	NA	NA	NA	2.81E-09
Benzoic Acid	1.16E-08	3.56E-10	5.25E-14	8.87E-15	2.84E-11	9.44E-13	9.66E-12	1.20E-08
Bis(2-ethylhexyl)phthalate	4.42E-09	3.23E-07	4.29E-09	2.12E-10	1.08E-11	1.49E-13	3.66E-12	3.32E-07
Bromodichloromethane	9.74E-09	NA	NA	NA	NA	NA	NA	9.74E-09
Butylbenzylphthalate	3.10E-09	3.89E-08	1.09E-12	1.28E-13	7.56E-12	6.22E-13	2.57E-12	4.20E-08
Carbon Tetrachloride	2.56E-09	NA	NA	NA	NA	NA	NA	2.56E-09
Chlorobenzene	2.49E-09	NA	NA	NA	NA	NA	NA	2.49E-09
Chloroform	4.44E-08	NA	NA	NA	NA	NA	NA	4.44E-08
Dibromochloromethane	1.81E-09	7.80E-11	1.17E-14	1.97E-15	4.41E-12	2.44E-13	1.50E-12	1.89E-09
Di-n-butylphthalate	6.64E-09	2.87E-11	1.72E-12	2.16E-13	1.62E-11	NA	5.50E-12	6.69E-09
Diethylphthalate	5.87E-09	1.97E-10	4.89E-14	8.23E-15	1.43E-11	NA	4.87E-12	6.08E-09
Dimethylphthalate	2.22E-09	1.49E-10	1.40E-14	2.36E-15	5.42E-12	NA	1.84E-12	2.38E-09
Dioxins/Furans (EPA TEFs)	9.33E-16	1.07E-18	4.72E-19	1.66E-19	2.27E-18	1.40E-18	7.74E-19	9.39E-16
Heptachlor epoxide	6.30E-11	1.21E-11	1.23E-14	1.64E-15	1.53E-13	2.81E-13	5.22E-14	7.56E-11
Methyl Chloride	3.19E-08	NA	NA	NA	NA	NA	NA	3.19E-08
Methylene Chloride	4.98E-09	NA	NA	NA	NA	NA	NA	4.98E-09
Styrene	2.40E-08	NA	NA	NA	NA	NA	NA	2.40E-08
Toluene	5.91E-09	NA	NA	NA	NA	NA	NA	5.91E-09
Xylene	2.45E-09	NA	NA	NA	NA	NA	NA	2.45E-09
INORGANICS								
Aluminum	8.47E-08	NA	NA	NA	NA	NE	NA	8.47E-08
Antimony	4.66E-09	4.34E-12	4.00E-14	1.90E-14	1.14E-11	NA	3.87E-13	4.68E-09
Arsenic	1.68E-08	1.15E-11	2.30E-11	1.30E-13	4.09E-11	1.93E-12	1.39E-12	1.69E-08
Barium	3.35E-08	NA	NA	NA	NA	NA	NA	3.35E-08
Boron	1.56E-07	NA	NA	NA	NA	NE	NA	1.56E-07
Cadmium	8.58E-10	1.68E-12	4.19E-13	7.92E-15	2.09E-12	NA	7.12E-14	8.63E-10
Calcium	8.38E-07	NA	NA	NA	NA	NE	NA	8.38E-07
Chromium III	1.61E-09	NA	NA	NA	NA	NA	NA	1.61E-09
Chromium VI	3.53E-10	NA	NA	NA	NA	NA	NA	3.53E-10
Copper	1.73E-06	5.02E-09	1.38E-09	4.12E-10	4.21E-09	6.37E-10	1.43E-10	1.74E-06
Iron	3.83E-08	NA	NA	NA	NA	NA	NA	3.83E-08
Lead	2.49E-08	NA	NA	NA	NA	NA	NA	2.49E-08

Table 8-12
(Continued)

Pollutant	Daily intake (mg/kg-day)							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total
Manganese	7.59E-09	NA	NA	NA	NA	NA	NA	7.59E-09
Mercury	6.00E-08	1.54E-10	1.16E-11	3.74E-10	1.46E-10	NA	4.98E-12	6.07E-08
Molybdenum	1.68E-08	NA	NA	NA	NA	NE	NA	1.68E-08
Nickel	6.70E-09	NA	NA	NA	NA	NA	NA	6.70E-09
Silver	1.67E-09	NA	NA	NA	NA	NA	NA	1.67E-09
Tin	1.13E-08	NA	NA	NA	NA	NE	NA	1.13E-08
Titanium	1.68E-08	NA	NA	NA	NA	NE	NA	1.68E-08
Vanadium	8.38E-09	NA	NA	NA	NA	2.56E-14	NA	8.38E-09
Zinc	4.33E-07	NA	NA	NA	NA	7.81E-11	NA	4.33E-07
CRITERIA POLLUTANTS/ ACID GASES								
Hydrogen Chloride	8.83E-06	NA	NA	NA	NA	NA	NA	8.83E-06
Particulate Matter	5.75E-05	NA	NA	NA	NA	NA	NA	5.75E-05
Carbon Monoxide	4.98E-05	NA	NA	NA	NA	NA	NA	4.98E-05
Hydrogen Fluoride	2.49E-07	NA	NA	NA	NA	NA	NA	2.49E-07
Nitric Acid	2.49E-07	NA	NA	NA	NA	NA	NA	2.49E-07
Nitrogen Oxide	2.11E-04	NA	NA	NA	NA	NA	NA	2.11E-04
Sulfur Dioxide	1.25E-04	NA	NA	NA	NA	NA	NA	1.25E-04

Table 8-13

Maximum Total Pollutant Daily Intake for Child, Resident-A Scenario

Pollutant	Daily intake (mg/kg-day)							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total
ORGANICS								
Benzene	2.81E-09	NA	NA	NA	NA	NA	NA	2.81E-09
Benzoic Acid	1.16E-08	6.08E-10	6.02E-14	9.33E-15	2.88E-11	9.44E-13	9.80E-12	1.23E-08
Bis(2-ethylhexyl)phthalate	4.42E-09	3.28E-07	1.49E-07	7.21E-09	1.09E-11	1.49E-13	3.72E-12	4.88E-07
Bromodichloromethane	9.74E-09	NA	NA	NA	NA	NA	NA	9.74E-09
Butylbenzylphthalate	3.10E-09	3.96E-08	1.68E-11	8.91E-13	7.67E-12	6.22E-13	2.61E-12	4.27E-08
Carbon Tetrachloride	2.56E-09	NA	NA	NA	NA	NA	NA	2.56E-09
Chlorobenzene	2.49E-09	NA	NA	NA	NA	NA	NA	2.49E-09
Chloroform	4.44E-08	NA	NA	NA	NA	NA	NA	4.44E-08
Dibromochloromethane	1.81E-09	1.18E-10	1.44E-14	2.12E-15	4.47E-12	2.44E-13	1.52E-12	1.93E-09
Di-n-butylphthalate	6.64E-09	1.70E-10	2.30E-11	1.25E-12	1.64E-11	NA	5.58E-12	6.85E-09
Diethylphthalate	5.87E-09	3.24E-10	6.45E-14	9.07E-15	1.45E-11	NA	4.94E-12	6.21E-09
Dimethylphthalate	2.22E-09	1.98E-10	1.71E-14	2.53E-15	5.50E-12	NA	1.87E-12	2.43E-09
Dioxins/Furans (EPA TEFs)	9.33E-16	2.09E-17	8.91E-18	1.52E-18	2.31E-18	1.40E-18	7.85E-19	9.69E-16
Heptachlor epoxide	6.30E-11	1.36E-11	1.40E-13	7.81E-15	1.56E-13	2.81E-13	5.30E-14	7.72E-11
Methyl Chloride	3.19E-08	NA	NA	NA	NA	NA	NA	3.19E-08
Methylene Chloride	4.98E-09	NA	NA	NA	NA	NA	NA	4.98E-09
Styrene	2.40E-08	NA	NA	NA	NA	NA	NA	2.40E-08
Toluene	5.91E-09	NA	NA	NA	NA	NA	NA	5.91E-09
Xylene	2.45E-09	NA	NA	NA	NA	NA	NA	2.45E-09
INORGANICS								
Aluminum	8.47E-08	NA	NA	NA	NA	NE	NA	8.47E-08
Antimony	4.66E-09	1.03E-10	5.02E-13	9.15E-14	1.15E-11	NA	3.93E-13	4.78E-09
Arsenic	1.68E-08	3.68E-10	1.23E-10	6.53E-13	4.15E-11	1.93E-12	1.41E-12	1.73E-08
Barium	3.35E-08	NA	NA	NA	NA	NA	NA	3.35E-08
Boron	1.56E-07	NA	NA	NA	NA	NE	NA	1.56E-07
Cadmium	8.58E-10	1.99E-11	1.27E-12	1.53E-14	2.12E-12	NA	7.22E-14	8.82E-10
Calcium	8.38E-07	NA	NA	NA	NA	NE	NA	8.38E-07
Chromium III	1.61E-09	NA	NA	NA	NA	NA	NA	1.61E-09
Chromium VI	3.53E-10	NA	NA	NA	NA	NA	NA	3.53E-10
Copper	1.73E-06	4.18E-08	3.97E-09	6.86E-10	4.27E-09	6.37E-10	1.45E-10	1.78E-06
Iron	3.83E-08	NA	NA	NA	NA	NA	NA	3.83E-08
Lead	2.49E-08	NA	NA	NA	NA	NA	NA	2.49E-08

Table 8-13
(Continued)

Pollutant	Daily intake (mg/kg-day)							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total
Manganese	7.59E-09	NA	NA	NA	NA	NA	NA	7.59E-09
Mercury	6.00E-08	1.43E-09	3.84E-11	6.12E-10	1.48E-10	NA	5.05E-12	6.22E-08
Molybdenum	1.68E-08	NA	NA	NA	NA	NE	NA	1.68E-08
Nickel	6.70E-09	NA	NA	NA	NA	NA	NA	6.70E-09
Silver	1.67E-09	NA	NA	NA	NA	NA	NA	1.67E-09
Tin	1.13E-08	NA	NA	NA	NA	NE	NA	1.13E-08
Titanium	1.68E-08	NA	NA	NA	NA	NE	NA	1.68E-08
Vanadium	8.38E-09	NA	NA	NA	NA	2.56E-14	NA	8.38E-09
Zinc	4.33E-07	NA	NA	NA	NA	7.81E-11	NA	4.33E-07
CRITERIA POLLUTANTS/ ACID GASES								
Hydrogen Chloride	8.83E-06	NA	NA	NA	NA	NA	NA	8.83E-06
Particulate Matter	5.75E-05	NA	NA	NA	NA	NA	NA	5.75E-05
Carbon Monoxide	4.98E-05	NA	NA	NA	NA	NA	NA	4.98E-05
Hydrogen Fluoride	2.49E-07	NA	NA	NA	NA	NA	NA	2.49E-07
Nitric Acid	2.49E-07	NA	NA	NA	NA	NA	NA	2.49E-07
Nitrogen Oxide	2.11E-04	NA	NA	NA	NA	NA	NA	2.11E-04
Sulfur Dioxide	1.25E-04	NA	NA	NA	NA	NA	NA	1.25E-04

Table 8-14

Average Total Pollutant Daily Intake for Child, Resident-B Scenario

Pollutant	Daily intake (mg/kg-day)							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total
ORGANICS								
Benzene	5.57E-10	NA	NA	NA	NA	NA	NA	5.57E-10
Benzoic Acid	2.31E-09	5.67E-10	5.25E-14	8.87E-15	4.61E-11	9.44E-13	1.57E-11	2.94E-09
Bis(2-ethylhexyl)phthalate	8.76E-10	5.25E-07	4.29E-09	2.12E-10	1.75E-11	1.49E-13	5.95E-12	5.30E-07
Bromodichloromethane	1.93E-09	NA	NA	NA	NA	NA	NA	1.93E-09
Butylbenzylphthalate	6.15E-10	6.32E-08	1.09E-12	1.28E-13	1.23E-11	6.22E-13	4.18E-12	6.39E-08
Carbon Tetrachloride	5.07E-10	NA	NA	NA	NA	NA	NA	5.07E-10
Chlorobenzene	4.94E-10	NA	NA	NA	NA	NA	NA	4.94E-10
Chloroform	8.80E-09	NA	NA	NA	NA	NA	NA	8.80E-09
Dibromochloromethane	3.59E-10	1.25E-10	1.17E-14	1.97E-15	7.16E-12	2.44E-13	2.44E-12	4.94E-10
Di-n-butylphthalate	1.32E-09	4.06E-11	1.72E-12	2.16E-13	2.63E-11	NA	8.94E-12	1.39E-09
Diethylphthalate	1.16E-09	3.15E-10	4.89E-14	8.23E-15	2.32E-11	NA	7.90E-12	1.51E-09
Dimethylphthalate	4.41E-10	2.40E-10	1.40E-14	2.36E-15	8.80E-12	NA	3.00E-12	6.92E-10
Dioxins/Furans (EPA TEFs)	1.85E-16	8.93E-19	4.72E-19	1.66E-19	3.69E-18	1.40E-18	1.26E-18	1.93E-16
Heptachlor epoxide	1.25E-11	1.96E-11	1.23E-14	1.64E-15	2.49E-13	2.81E-13	8.48E-14	3.28E-11
Methyl Chloride	6.33E-09	NA	NA	NA	NA	NA	NA	6.33E-09
Methylene Chloride	9.88E-10	NA	NA	NA	NA	NA	NA	9.88E-10
Styrene	4.76E-09	NA	NA	NA	NA	NA	NA	4.76E-09
Toluene	1.17E-09	NA	NA	NA	NA	NA	NA	1.17E-09
Xylene	4.85E-10	NA	NA	NA	NA	NA	NA	4.85E-10
INORGANICS								
Aluminum	1.68E-08	NA	NA	NA	NA	NE	NA	1.68E-08
Antimony	9.25E-10	2.83E-12	4.00E-14	1.90E-14	1.85E-11	NA	6.29E-13	9.47E-10
Arsenic	3.33E-09	3.49E-12	2.30E-11	1.30E-13	6.65E-11	1.93E-12	2.26E-12	3.43E-09
Barium	6.65E-09	NA	NA	NA	NA	NA	NA	6.65E-09
Boron	3.10E-08	NA	NA	NA	NA	NE	NA	3.10E-08
Cadmium	1.70E-10	1.96E-12	4.19E-13	7.92E-15	3.40E-12	NA	1.16E-13	1.76E-10
Calcium	1.66E-07	NA	NA	NA	NA	NE	NA	1.66E-07
Chromium III	3.19E-10	NA	NA	NA	NA	NA	NA	3.19E-10
Chromium VI	7.00E-11	NA	NA	NA	NA	NA	NA	7.00E-11
Copper	3.43E-07	6.58E-09	1.38E-09	4.12E-10	6.84E-09	6.37E-10	2.33E-10	3.59E-07
Iron	7.59E-09	NA	NA	NA	NA	NA	NA	7.59E-09
Lead	4.94E-09	NA	NA	NA	NA	NA	NA	4.94E-09

Table 8-14
(Continued)

Pollutant	Daily intake (mg/kg-day)							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total
Manganese	1.50E-09	NA	NA	NA	NA	NA	NA	1.50E-09
Mercury	1.19E-08	1.97E-10	1.16E-11	3.74E-10	2.37E-10	NA	8.09E-12	1.27E-08
Molybdenum	3.33E-09	NA	NA	NA	NA	NE	NA	3.33E-09
Nickel	1.33E-09	NA	NA	NA	NA	NA	NA	1.33E-09
Silver	3.30E-10	NA	NA	NA	NA	NA	NA	3.30E-10
Tin	2.24E-09	NA	NA	NA	NA	NE	NA	2.24E-09
Titanium	3.33E-09	NA	NA	NA	NA	NE	NA	3.33E-09
Vanadium	1.66E-09	NA	NA	NA	NA	2.56E-14	NA	1.66E-09
Zinc	8.58E-08	NA	NA	NA	NA	7.81E-11	NA	8.58E-08
CRITERIA POLLUTANTS/ ACID GASES								
Hydrogen Chloride	1.75E-06	NA	NA	NA	NA	NA	NA	1.75E-06
Particulate Matter	1.14E-05	NA	NA	NA	NA	NA	NA	1.14E-05
Carbon Monoxide	9.88E-06	NA	NA	NA	NA	NA	NA	9.88E-06
Hydrogen Fluoride	4.94E-08	NA	NA	NA	NA	NA	NA	4.94E-08
Nitric Acid	4.94E-08	NA	NA	NA	NA	NA	NA	4.94E-08
Nitrogen Oxide	4.18E-05	NA	NA	NA	NA	NA	NA	4.18E-05
Sulfur Dioxide	2.47E-05	NA	NA	NA	NA	NA	NA	2.47E-05

Table 8-15

Maximum Total Pollutant Daily Intake for Child, Resident-B Scenario

Pollutant	Daily intake (mg/kg-day)							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total
ORGANICS								
Benzene	5.57E-10	NA	NA	NA	NA	NA	NA	5.57E-10
Benzoic Acid	2.31E-09	6.18E-10	6.02E-14	9.33E-15	4.67E-11	9.44E-13	1.59E-11	2.99E-09
Bis(2-ethylhexyl)phthalate	8.76E-10	5.32E-07	1.49E-07	7.21E-09	1.77E-11	1.49E-13	6.04E-12	6.90E-07
Bromodichloromethane	1.93E-09	NA	NA	NA	NA	NA	NA	1.93E-09
Butylbenzylphthalate	6.15E-10	6.42E-08	1.68E-11	8.91E-13	1.25E-11	6.22E-13	4.24E-12	6.48E-08
Carbon Tetrachloride	5.07E-10	NA	NA	NA	NA	NA	NA	5.07E-10
Chlorobenzene	4.94E-10	NA	NA	NA	NA	NA	NA	4.94E-10
Chloroform	8.80E-09	NA	NA	NA	NA	NA	NA	8.80E-09
Dibromochloromethane	3.59E-10	1.34E-10	1.44E-14	2.12E-15	7.26E-12	2.44E-13	2.47E-12	5.02E-10
Di-n-butylphthalate	1.32E-09	6.56E-11	2.30E-11	1.25E-12	2.66E-11	NA	9.07E-12	1.44E-09
Diethylphthalate	1.16E-09	3.41E-10	6.45E-14	9.07E-15	2.35E-11	NA	8.02E-12	1.54E-09
Dimethylphthalate	4.41E-10	2.51E-10	1.71E-14	2.53E-15	8.93E-12	NA	3.04E-12	7.04E-10
Dioxins/Furans (EPA TEFs)	1.85E-16	4.34E-18	8.91E-18	1.52E-18	3.75E-18	1.40E-18	1.28E-18	2.06E-16
Heptachlor epoxide	1.25E-11	2.02E-11	1.40E-13	7.81E-15	2.53E-13	2.81E-13	8.61E-14	3.34E-11
Methyl Chloride	6.33E-09	NA	NA	NA	NA	NA	NA	6.33E-09
Methylene Chloride	9.88E-10	NA	NA	NA	NA	NA	NA	9.88E-10
Styrene	4.76E-09	NA	NA	NA	NA	NA	NA	4.76E-09
Toluene	1.17E-09	NA	NA	NA	NA	NA	NA	1.17E-09
Xylene	4.85E-10	NA	NA	NA	NA	NA	NA	4.85E-10
INORGANICS								
Aluminum	1.68E-08	NA	NA	NA	NA	NE	NA	1.68E-08
Antimony	9.25E-10	2.00E-11	5.02E-13	9.15E-14	1.87E-11	NA	6.38E-13	9.65E-10
Arsenic	3.33E-09	6.54E-11	1.23E-10	6.53E-13	6.75E-11	1.93E-12	2.30E-12	3.59E-09
Barium	6.65E-09	NA	NA	NA	NA	NA	NA	6.65E-09
Boron	3.10E-08	NA	NA	NA	NA	NE	NA	3.10E-08
Cadmium	1.70E-10	5.15E-12	1.27E-12	1.53E-14	3.45E-12	NA	1.17E-13	1.80E-10
Calcium	1.66E-07	NA	NA	NA	NA	NE	NA	1.66E-07
Chromium III	3.19E-10	NA	NA	NA	NA	NA	NA	3.19E-10
Chromium VI	7.00E-11	NA	NA	NA	NA	NA	NA	7.00E-11
Copper	3.43E-07	1.30E-08	3.97E-09	6.86E-10	6.94E-09	6.37E-10	2.36E-10	3.68E-07
Iron	7.59E-09	NA	NA	NA	NA	NA	NA	7.59E-09
Lead	4.94E-09	NA	NA	NA	NA	NA	NA	4.94E-09

Table 8-15
(Continued)

Pollutant	Daily intake (mg/kg-day)							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total
Manganese	1.50E-09	NA	NA	NA	NA	NA	NA	1.50E-09
Mercury	1.19E-08	4.20E-10	3.84E-11	6.12E-10	2.41E-10	NA	8.21E-12	1.32E-08
Molybdenum	3.33E-09	NA	NA	NA	NA	NE	NA	3.33E-09
Nickel	1.33E-09	NA	NA	NA	NA	NA	NA	1.33E-09
Silver	3.30E-10	NA	NA	NA	NA	NA	NA	3.30E-10
Tin	2.24E-09	NA	NA	NA	NA	NE	NA	2.24E-09
Titanium	3.33E-09	NA	NA	NA	NA	NE	NA	3.33E-09
Vanadium	1.66E-09	NA	NA	NA	NA	2.56E-14	NA	1.66E-09
Zinc	8.58E-08	NA	NA	NA	NA	7.81E-11	NA	8.58E-08
CRITERIA POLLUTANTS/ ACID GASES								
Hydrogen Chloride	1.75E-06	NA	NA	NA	NA	NA	NA	1.75E-06
Particulate Matter	1.14E-05	NA	NA	NA	NA	NA	NA	1.14E-05
Carbon Monoxide	9.88E-06	NA	NA	NA	NA	NA	NA	9.88E-06
Hydrogen Fluoride	4.94E-08	NA	NA	NA	NA	NA	NA	4.94E-08
Nitric Acid	4.94E-08	NA	NA	NA	NA	NA	NA	4.94E-08
Nitrogen Oxide	4.18E-05	NA	NA	NA	NA	NA	NA	4.18E-05
Sulfur Dioxide	2.47E-05	NA	NA	NA	NA	NA	NA	2.47E-05

Table 8-16

Average Total Pollutant Daily Intake for Child, Farmer Scenario

Pollutant	Daily intake (mg/kg-day)							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total
ORGANICS								
Benzene	9.76E-10	NA	NA	NA	NA	NA	NA	9.76E-10
Benzoic Acid	4.05E-09	1.32E-09	1.05E-12	1.77E-13	2.75E-11	9.44E-13	9.37E-12	5.40E-09
Bis(2-ethylhexyl)phthalate	1.53E-09	3.90E-06	8.58E-08	4.24E-09	1.04E-11	1.49E-13	3.56E-12	3.99E-06
Bromodichloromethane	3.38E-09	NA	NA	NA	NA	NA	NA	3.38E-09
Butylbenzylphthalate	1.08E-09	4.70E-07	2.17E-11	2.56E-12	7.34E-12	6.22E-13	2.50E-12	4.71E-07
Carbon Tetrachloride	8.89E-10	NA	NA	NA	NA	NA	NA	8.89E-10
Chlorobenzene	8.66E-10	NA	NA	NA	NA	NA	NA	8.66E-10
Chloroform	1.54E-08	NA	NA	NA	NA	NA	NA	1.54E-08
Dibromochloromethane	6.29E-10	6.55E-10	2.34E-13	3.95E-14	4.28E-12	2.44E-13	1.46E-12	1.29E-09
Di-n-butylphthalate	2.31E-09	2.88E-10	3.45E-11	4.33E-12	1.57E-11	NA	5.34E-12	2.65E-09
Diethylphthalate	2.04E-09	1.71E-09	9.78E-13	1.65E-13	1.39E-11	NA	4.72E-12	3.77E-09
Dimethylphthalate	7.73E-10	1.43E-09	2.79E-13	4.71E-14	5.26E-12	NA	1.79E-12	2.21E-09
Dioxins/Furans (EPA TEFs)	3.24E-16	5.38E-18	9.44E-18	3.32E-18	2.21E-18	1.40E-18	7.51E-19	3.47E-16
Heptachlor epoxide	2.19E-11	1.46E-10	2.47E-13	3.27E-14	1.49E-13	2.81E-13	5.07E-14	1.69E-10
Methyl Chloride	1.11E-08	NA	NA	NA	NA	NA	NA	1.11E-08
Methylene Chloride	1.73E-09	NA	NA	NA	NA	NA	NA	1.73E-09
Styrene	8.34E-09	NA	NA	NA	NA	NA	NA	8.34E-09
Toluene	2.05E-09	NA	NA	NA	NA	NA	NA	2.05E-09
Xylene	8.50E-10	NA	NA	NA	NA	NA	NA	8.50E-10
INORGANICS								
Aluminum	2.94E-08	NA	NA	NA	NA	NE	NA	2.94E-08
Antimony	1.62E-09	6.14E-12	8.01E-13	3.81E-13	1.10E-11	NA	3.76E-13	1.64E-09
Arsenic	5.84E-09	8.90E-12	4.61E-10	2.61E-12	3.97E-11	1.93E-12	1.35E-12	6.36E-09
Barium	1.16E-08	NA	NA	NA	NA	NA	NA	1.16E-08
Boron	5.43E-08	NA	NA	NA	NA	NE	NA	5.43E-08
Cadmium	2.98E-10	4.25E-12	8.39E-12	1.58E-13	2.03E-12	NA	6.91E-14	3.13E-10
Calcium	2.91E-07	NA	NA	NA	NA	NE	NA	2.91E-07
Chromium III	5.60E-10	NA	NA	NA	NA	NA	NA	5.60E-10
Chromium VI	1.23E-10	NA	NA	NA	NA	NA	NA	1.23E-10
Copper	6.01E-07	1.40E-08	2.77E-08	8.25E-09	4.09E-09	6.37E-10	1.39E-10	6.55E-07
Iron	1.33E-08	NA	NA	NA	NA	NA	NA	1.33E-08
Lead	8.66E-09	NA	NA	NA	NA	NA	NA	8.66E-09

Table 8-16
(Continued)

Pollutant	Daily intake (mg/kg-day)							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total
Manganese	2.64E-09	NA	NA	NA	NA	NA	NA	2.64E-09
Mercury	2.09E-08	4.05E-10	2.31E-10	7.48E-09	1.42E-10	NA	4.83E-12	2.91E-08
Molybdenum	5.84E-09	NA	NA	NA	NA	NE	NA	5.84E-09
Nickel	2.33E-09	NA	NA	NA	NA	NA	NA	2.33E-09
Silver	5.79E-10	NA	NA	NA	NA	NA	NA	5.79E-10
Tin	3.92E-09	NA	NA	NA	NA	NE	NA	3.92E-09
Titanium	5.84E-09	NA	NA	NA	NA	NE	NA	5.84E-09
Vanadium	2.91E-09	NA	NA	NA	NA	2.56E-14	NA	2.91E-09
Zinc	1.50E-07	NA	NA	NA	NA	7.81E-11	NA	1.50E-07
CRITERIA POLLUTANTS/ ACID GASES								
Hydrogen Chloride	3.07E-06	NA	NA	NA	NA	NA	NA	3.07E-06
Particulate Matter	2.00E-05	NA	NA	NA	NA	NA	NA	2.00E-05
Carbon Monoxide	1.73E-05	NA	NA	NA	NA	NA	NA	1.73E-05
Hydrogen Fluoride	8.66E-08	NA	NA	NA	NA	NA	NA	8.66E-08
Nitric Acid	8.66E-08	NA	NA	NA	NA	NA	NA	8.66E-08
Nitrogen Oxide	7.32E-05	NA	NA	NA	NA	NA	NA	7.32E-05
Sulfur Dioxide	4.33E-05	NA	NA	NA	NA	NA	NA	4.33E-05

Table 8-17

Maximum Total Pollutant Daily Intake for Child, Farmer Scenario

Pollutant	Daily intake (mg/kg-day)							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total
ORGANICS								
Benzene	9.76E-10	NA	NA	NA	NA	NA	NA	9.76E-10
Benzoic Acid	4.05E-09	1.47E-09	1.20E-12	1.87E-13	2.79E-11	9.44E-13	9.51E-12	5.56E-09
Bis(2-ethylhexyl)phthalate	1.53E-09	3.96E-06	2.98E-06	1.44E-07	1.06E-11	1.49E-13	3.61E-12	7.08E-06
Bromodichloromethane	3.38E-09	NA	NA	NA	NA	NA	NA	3.38E-09
Butylbenzylphthalate	1.08E-09	4.77E-07	3.37E-10	1.78E-11	7.44E-12	6.22E-13	2.53E-12	4.78E-07
Carbon Tetrachloride	8.89E-10	NA	NA	NA	NA	NA	NA	8.89E-10
Chlorobenzene	8.66E-10	NA	NA	NA	NA	NA	NA	8.66E-10
Chloroform	1.54E-08	NA	NA	NA	NA	NA	NA	1.54E-08
Dibromochloromethane	6.29E-10	6.85E-10	2.88E-13	4.25E-14	4.34E-12	2.44E-13	1.48E-12	1.32E-09
Di-n-butylphthalate	2.31E-09	3.67E-10	4.60E-10	2.49E-11	1.59E-11	NA	5.42E-12	3.18E-09
Diethylphthalate	2.04E-09	1.80E-09	1.29E-12	1.81E-13	1.41E-11	NA	4.79E-12	3.86E-09
Dimethylphthalate	7.73E-10	1.47E-09	3.41E-13	5.06E-14	5.34E-12	NA	1.82E-12	2.25E-09
Dioxins/Furans (EPA TEFs)	3.24E-16	1.60E-17	1.78E-16	3.05E-17	2.24E-18	1.40E-18	7.62E-19	5.53E-16
Heptachlor epoxide	2.19E-11	1.49E-10	2.79E-12	1.56E-13	1.51E-13	2.81E-13	5.14E-14	1.74E-10
Methyl Chloride	1.11E-08	NA	NA	NA	NA	NA	NA	1.11E-08
Methylene Chloride	1.73E-09	NA	NA	NA	NA	NA	NA	1.73E-09
Styrene	8.34E-09	NA	NA	NA	NA	NA	NA	8.34E-09
Toluene	2.05E-09	NA	NA	NA	NA	NA	NA	2.05E-09
Xylene	8.50E-10	NA	NA	NA	NA	NA	NA	8.50E-10
INORGANICS								
Aluminum	2.94E-08	NA	NA	NA	NA	NE	NA	2.94E-08
Antimony	1.62E-09	5.90E-11	1.00E-11	1.83E-12	1.12E-11	NA	3.81E-13	1.70E-09
Arsenic	5.84E-09	1.99E-10	2.46E-09	1.31E-11	4.03E-11	1.93E-12	1.37E-12	8.56E-09
Barium	1.16E-08	NA	NA	NA	NA	NA	NA	1.16E-08
Boron	5.43E-08	NA	NA	NA	NA	NE	NA	5.43E-08
Cadmium	2.98E-10	1.40E-11	2.55E-11	3.07E-13	2.06E-12	NA	7.01E-14	3.40E-10
Calcium	2.91E-07	NA	NA	NA	NA	NE	NA	2.91E-07
Chromium III	5.60E-10	NA	NA	NA	NA	NA	NA	5.60E-10
Chromium VI	1.23E-10	NA	NA	NA	NA	NA	NA	1.23E-10
Copper	6.01E-07	3.38E-08	7.93E-08	1.37E-08	4.15E-09	6.37E-10	1.41E-10	7.32E-07
Iron	1.33E-08	NA	NA	NA	NA	NA	NA	1.33E-08
Lead	8.66E-09	NA	NA	NA	NA	NA	NA	8.66E-09

Table 8-17
(Continued)

Pollutant	Daily intake (mg/kg-day)							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total
Manganese	2.64E-09	NA	NA	NA	NA	NA	NA	2.64E-09
Mercury	2.09E-08	1.09E-09	7.69E-10	1.22E-08	1.44E-10	NA	4.90E-12	3.51E-08
Molybdenum	5.84E-09	NA	NA	NA	NA	NE	NA	5.84E-09
Nickel	2.33E-09	NA	NA	NA	NA	NA	NA	2.33E-09
Silver	5.79E-10	NA	NA	NA	NA	NA	NA	5.79E-10
Tin	3.92E-09	NA	NA	NA	NA	NE	NA	3.92E-09
Titanium	5.84E-09	NA	NA	NA	NA	NE	NA	5.84E-09
Vanadium	2.91E-09	NA	NA	NA	NA	2.56E-14	NA	2.91E-09
Zinc	1.50E-07	NA	NA	NA	NA	7.81E-11	NA	1.50E-07
CRITERIA POLLUTANTS/ ACID GASES								
Hydrogen Chloride	3.07E-06	NA	NA	NA	NA	NA	NA	3.07E-06
Particulate Matter	2.00E-05	NA	NA	NA	NA	NA	NA	2.00E-05
Carbon Monoxide	1.73E-05	NA	NA	NA	NA	NA	NA	1.73E-05
Hydrogen Fluoride	8.66E-08	NA	NA	NA	NA	NA	NA	8.66E-08
Nitric Acid	8.66E-08	NA	NA	NA	NA	NA	NA	8.66E-08
Nitrogen Oxide	7.32E-05	NA	NA	NA	NA	NA	NA	7.32E-05
Sulfur Dioxide	4.33E-05	NA	NA	NA	NA	NA	NA	4.33E-05

Table 8-18

Maximum Total Pollutant Daily Intake for the Infant, Resident-A Scenario

Pollutant	Daily Intake (mg/kg-day) Inhalation	Breast Milk Ingestion	Total
ORGANICS			
Benzene	1.84E-09	2.13E-12	1.84E-09
Benzoic Acid	7.62E-09	7.50E-09	1.51E-08
Bis(2-ethylhexyl)phthalate	2.89E-09	1.71E-09	4.60E-09
Bromodichloromethane	6.37E-09	1.47E-10	6.52E-09
Butylbenzylphthalate	2.03E-09	3.80E-09	5.83E-09
Carbon Tetrachloride	1.67E-09	3.88E-11	1.71E-09
Chlorobenzene	1.63E-09	3.77E-11	1.67E-09
Chloroform	2.90E-08	6.72E-10	2.97E-08
Dibromochloromethane	1.18E-09	3.97E-11	1.22E-09
Di-n-butylphthalate	4.34E-09	4.16E-10	4.76E-09
Diethylphthalate	3.84E-09	3.81E-10	4.22E-09
Dimethylphthalate	1.46E-09	1.51E-10	1.61E-09
Dioxins/Furans (EPA TEFs)	6.11E-16	1.24E-14	1.30E-14
Heptachlor epoxide	4.12E-11	5.06E-11	9.18E-11
Methyl Chloride	2.09E-08	4.84E-10	2.14E-08
Methylene Chloride	3.26E-09	7.55E-11	3.34E-09
Styrene	1.57E-08	3.64E-10	1.61E-08
Toluene	3.87E-09	1.12E-11	3.88E-09
Xylene	1.60E-09	9.26E-13	1.60E-09
INORGANICS			
Aluminum	5.54E-08	NE	5.54E-08
Antimony	3.05E-09	NE	3.05E-09
Arsenic	1.10E-08	NE	1.10E-08
Barium	2.19E-08	NE	2.19E-08
Boron	1.02E-07	NE	1.02E-07
Cadmium	5.62E-10	NE	5.62E-10
Calcium	5.48E-07	NE	5.48E-07
Chromium III	1.05E-09	NE	1.05E-09
Chromium VI	2.31E-10	NE	2.31E-10
Copper	1.13E-06	NE	1.13E-06
Iron	2.50E-08	NE	2.50E-08
Lead	1.63E-08	NE	1.63E-08
Manganese	4.96E-09	NE	4.96E-09
Mercury	3.93E-08	NE	3.93E-08
Molybdenum	1.10E-08	NE	1.10E-08
Nickel	4.39E-09	NE	4.39E-09
Silver	1.09E-09	NE	1.09E-09
Tin	7.38E-09	NE	7.38E-09
Titanium	1.10E-08	NE	1.10E-08
Vanadium	5.48E-09	NE	5.48E-09
Zinc	2.83E-07	NE	2.83E-07
CRITERIA POLLUTANTS/ ACID GASES			
Hydrogen Chloride	5.78E-06	NA	5.78E-06
Particulate Matter	3.76E-05	NA	3.76E-05
Carbon Monoxide	3.26E-05	NA	3.26E-05
Hydrogen Fluoride	1.63E-07	NA	1.63E-07
Nitric Acid	1.63E-07	NA	1.63E-07
Nitrogen Oxide	1.38E-04	NA	1.38E-04
Sulfur Dioxide	8.15E-05	NA	8.15E-05

Table 8-19

Maximum Total Pollutant Daily Intake for the Infant, Resident-B Scenario

Pollutant	Daily Intake (mg/kg-day) Inhalation	Breast Milk Ingestion	Total
ORGANICS			
Benzene	3.64E-10	4.22E-13	3.65E-10
Benzoic Acid	1.51E-09	1.85E-09	3.36E-09
Bis(2-ethylhexyl)phthalate	5.73E-10	2.63E-09	3.20E-09
Bromodichloromethane	1.26E-09	2.92E-11	1.29E-09
Butylbenzylphthalate	4.03E-10	5.90E-09	6.30E-09
Carbon Tetrachloride	3.32E-10	7.69E-12	3.40E-10
Chlorobenzene	3.23E-10	7.48E-12	3.31E-10
Chloroform	5.76E-09	1.33E-10	5.89E-09
Dibromochloromethane	2.35E-10	1.09E-11	2.46E-10
Di-n-butylphthalate	8.61E-10	8.64E-11	9.47E-10
Diethylphthalate	7.61E-10	9.91E-11	8.60E-10
Dimethylphthalate	2.89E-10	4.82E-11	3.37E-10
Dioxins/Furans (EPA TEFs)	1.21E-16	2.54E-15	2.66E-15
Heptachlor epoxide	8.17E-12	2.62E-11	3.44E-11
Methyl Chloride	4.14E-09	9.59E-11	4.24E-09
Methylene Chloride	6.47E-10	1.50E-11	6.61E-10
Styrene	3.11E-09	7.21E-11	3.19E-09
Toluene	7.67E-10	2.22E-12	7.69E-10
Xylene	3.17E-10	1.84E-13	3.18E-10
INORGANICS			
Aluminum	1.10E-08	NE	1.10E-08
Antimony	6.05E-10	NE	6.05E-10
Arsenic	2.18E-09	NE	2.18E-09
Barium	4.35E-09	NE	4.35E-09
Boron	2.03E-08	NE	2.03E-08
Cadmium	1.11E-10	NE	1.11E-10
Calcium	1.09E-07	NE	1.09E-07
Chromium III	2.09E-10	NE	2.09E-10
Chromium VI	4.58E-11	NE	4.58E-11
Copper	2.24E-07	NE	2.24E-07
Iron	4.97E-09	NE	4.97E-09
Lead	3.23E-09	NE	3.23E-09
Manganese	9.84E-10	NE	9.84E-10
Mercury	7.79E-09	NE	7.79E-09
Molybdenum	2.18E-09	NE	2.18E-09
Nickel	8.70E-10	NE	8.70E-10
Silver	2.16E-10	NE	2.16E-10
Tin	1.46E-09	NE	1.46E-09
Titanium	2.18E-09	NE	2.18E-09
Vanadium	1.09E-09	NE	1.09E-09
Zinc	5.61E-08	NE	5.61E-08
CRITERIA POLLUTANTS/ ACID GASES			
Hydrogen Chloride	1.15E-06	NA	1.15E-06
Particulate Matter	7.46E-06	NA	7.46E-06
Carbon Monoxide	6.47E-06	NA	6.47E-06
Hydrogen Fluoride	3.23E-08	NA	3.23E-08
Nitric Acid	3.23E-08	NA	3.23E-08
Nitrogen Oxide	2.73E-05	NA	2.73E-05
Sulfur Dioxide	1.62E-05	NA	1.62E-05

Table 8-20

Maximum Total Pollutant Daily Intake for the Infant, Farmer Scenario

Pollutant	Daily Intake (mg/kg-day) Inhalation	Breast Milk Ingestion	Total
ORGANICS			
Benzene	6.39E-10	7.39E-13	6.39E-10
Benzoic Acid	2.65E-09	3.42E-09	6.07E-09
Bis(2-ethylhexyl)phthalate	1.00E-09	1.65E-08	1.75E-08
Bromodichloromethane	2.21E-09	5.13E-11	2.27E-09
Butylbenzylphthalate	7.06E-10	3.04E-08	3.11E-08
Carbon Tetrachloride	5.82E-10	1.35E-11	5.96E-10
Chlorobenzene	5.67E-10	1.31E-11	5.80E-10
Chloroform	1.01E-08	2.34E-10	1.03E-08
Dibromochloromethane	4.12E-10	2.74E-11	4.39E-10
Di-n-butylphthalate	1.51E-09	1.77E-10	1.69E-09
Diethylphthalate	1.33E-09	2.39E-10	1.57E-09
Dimethylphthalate	5.06E-10	1.41E-10	6.47E-10
Dioxins/Furans (EPA TEFs)	2.12E-16	5.56E-15	5.77E-15
Heptachlor epoxide	1.43E-11	1.09E-10	1.23E-10
Methyl Chloride	7.26E-09	1.68E-10	7.43E-09
Methylene Chloride	1.13E-09	2.62E-11	1.16E-09
Styrene	5.46E-09	1.26E-10	5.59E-09
Toluene	1.34E-09	3.89E-12	1.35E-09
Xylene	5.56E-10	3.22E-13	5.57E-10
INORGANICS			
Aluminum	1.93E-08	NE	1.93E-08
Antimony	1.06E-09	NE	1.06E-09
Arsenic	3.82E-09	NE	3.82E-09
Barium	7.62E-09	NE	7.62E-09
Boron	3.55E-08	NE	3.55E-08
Cadmium	1.95E-10	NE	1.95E-10
Calcium	1.91E-07	NE	1.91E-07
Chromium III	3.66E-10	NE	3.66E-10
Chromium VI	8.04E-11	NE	8.04E-11
Copper	3.93E-07	NE	3.93E-07
Iron	8.71E-09	NE	8.71E-09
Lead	5.67E-09	NE	5.67E-09
Manganese	1.73E-09	NE	1.73E-09
Mercury	1.37E-08	NE	1.37E-08
Molybdenum	3.82E-09	NE	3.82E-09
Nickel	1.52E-09	NE	1.52E-09
Silver	3.79E-10	NE	3.79E-10
Tin	2.57E-09	NE	2.57E-09
Titanium	3.82E-09	NE	3.82E-09
Vanadium	1.91E-09	NE	1.91E-09
Zinc	9.84E-08	NE	9.84E-08
CRITERIA POLLUTANTS/ ACID GASES			
Hydrogen Chloride	2.01E-06	NA	2.01E-06
Particulate Matter	1.31E-05	NA	1.31E-05
Carbon Monoxide	1.13E-05	NA	1.13E-05
Hydrogen Fluoride	5.67E-08	NA	5.67E-08
Nitric Acid	5.67E-08	NA	5.67E-08
Nitrogen Oxide	4.79E-05	NA	4.79E-05
Sulfur Dioxide	2.83E-05	NA	2.83E-05

SECTION 9

TOXICITY ASSESSMENT

9.1 INTRODUCTION

The purpose of the human health toxicity assessment is to assign "toxicity values" to each pollutant evaluated in the human health risk assessment. The toxicity values are then used in combination with the calculated dose to which the RMEI is exposed (Section 8) to evaluate the potential human health risks associated with the pollutant (Section 10).

The following general procedure and rationale for the toxicity assessment were used for this risk assessment:

- For chemicals both detected in the trial burn and predicted in the 1991 risk assessment, toxicity values as used in the 1991 draft were employed. (An analysis of changes in toxicity values since 1991 showed that there would be no significant impact on cancer or noncancer risk [WESTON, 1993]). These values had been previously approved by EPA Region VIII.

- For noncarcinogenic chemicals that were detected in the trial burn, but were not predicted to be present based on the 1991 report, reference doses were derived as described below and according to EPA (1992) and IRIS (1993). EPA Region VIII has approved these values. There were no new carcinogens.

Based on emissions data from the recently completed SQI trial burn, a list of chemicals to be evaluated was established (Section 5). These chemicals were then screened in the pollutant/pathways analysis (Section 7). Based on the specific pathways to which each chemical was assigned, the route-specific toxicity criteria were determined.

9.2 CARCINOGENIC AND NONCARCINOGENIC RISK-BASED TOXICITY VALUES

In evaluating potential health risks, both carcinogenic and noncarcinogenic health effects must be considered. The potential for producing carcinogenic effects is limited to substances that have been shown to be carcinogenic in animals and/or humans. Excessive exposure to all pollutants, carcinogens and noncarcinogens, can produce adverse noncarcinogenic health effects. Therefore, it is necessary to identify and select noncancer toxicity values (reference doses) for each contaminant selected for evaluation and to identify and select cancer toxicity values (cancer slope factors) for those chemicals that show evidence of carcinogenic activity.

9.2.1 Carcinogenic Risk-Based Toxicity Values

The toxicity values that were used in the evaluation of carcinogenic risks in Section 10 are carcinogenic slope factors developed by EPA (1990). EPA develops carcinogenic slope factors under the assumption that the risk of cancer is linearly related to dose. Typically, EPA develops cancer slope factors from laboratory animal studies in which relatively high doses were administered or from epidemiological studies where a population is exposed to the chemical. It is conservatively assumed that these high doses can be extrapolated down to extremely small doses, with some incremental risk of cancer always remaining. Figure 9-1 illustrates this approach. This "nonthreshold" theory assumes that even a small number of molecules (possibly a single molecule) of a carcinogen may cause changes in a single cell that could result in the cell dividing in an uncontrolled manner and eventually lead to cancer. The slope factors are usually derived by EPA using a linearized multistage model and reflect the upper-bound limit of the cancer potency of any chemical. As a result, the calculated carcinogenic risk is likely to represent a plausible upper limit to the risk. The actual risk is unknown, but is likely to be lower than the predicted risk, and may be even as low as zero (EPA, 1986a; 1989).

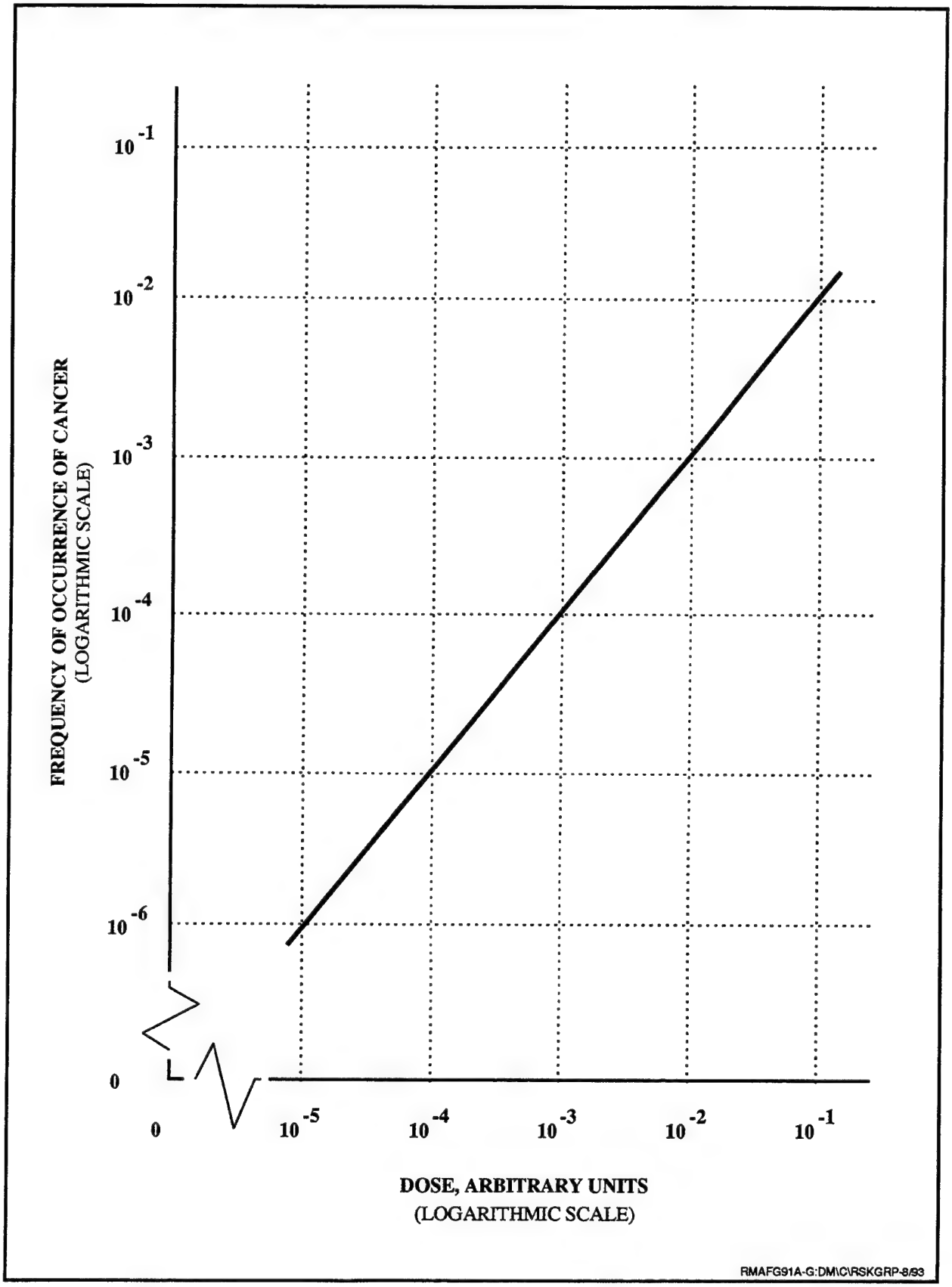


FIGURE 9-1 HYPOTHETICAL DOSE-RESPONSE CURVE FOR A "NO THRESHOLD" OR CARCINOGENIC CHEMICAL

There is some dispute as to whether the extrapolation from high to low doses is a realistic approach. It has been argued that at low doses cells may have the ability to detoxify carcinogens or repair cellular damage. Although it is important to recognize the possibility that some carcinogens may have a threshold for toxicity, this argument was not considered in the actual calculation of the risk. It is important that this risk assessment use the same EPA approach for calculating carcinogenic risk as in other risk assessments. By using this approach, predicted risks for all scenarios and for all sites can be accurately compared.

9.2.2 Noncarcinogenic Risk-Based Toxicity Values

The toxicity values used to evaluate the potential for noncarcinogenic health effects are generically referred to in this document as reference doses (RfDs). Unlike the approach used in evaluating carcinogenic risk, it is assumed that a threshold dose exists below which there is no appreciable potential for toxicity. The term RfD was developed by EPA to refer to the daily intake of a chemical to which an individual can be exposed without any expectation of noncarcinogenic adverse health effects occurring (e.g., organ damage, biochemical alterations, birth defects). The term is used in this assessment to apply to any established or derived toxicity value fitting this description. In general terms, the RfD is derived from a NOAEL (no-observed-adverse-effect level) or LOAEL (lowest-observed-adverse-effect level) obtained from human or animal studies by the application of standard order-of-magnitude uncertainty factors, and in certain cases, an additional modifying factor to account for professional assessment of scientific uncertainties in the available data (EPA, 1989).

A "no-observed-adverse-effect level" (NOAEL) is that dose of chemical at which no toxic effects are observed in any of the test subjects. The study chosen to establish the NOAEL is based on the criterion that the measured toxic endpoint represents the most sensitive target organ or tissue (i.e., critical organ) to that chemical. Since many chemicals can produce toxic effects on several organ systems, with each toxic effect possibly having a

separate threshold dose, the distinction of the "critical" toxic effect provides added confidence that the NOAEL is protective of human health. Figure 9-2 illustrates this "threshold" theory. A variety of regulatory agencies have used the threshold approach for noncarcinogenic substances in the development of health effects criteria, such as worker-related threshold limit values (TLVs), air quality standards, FDA food additive regulations, and drinking water regulations.

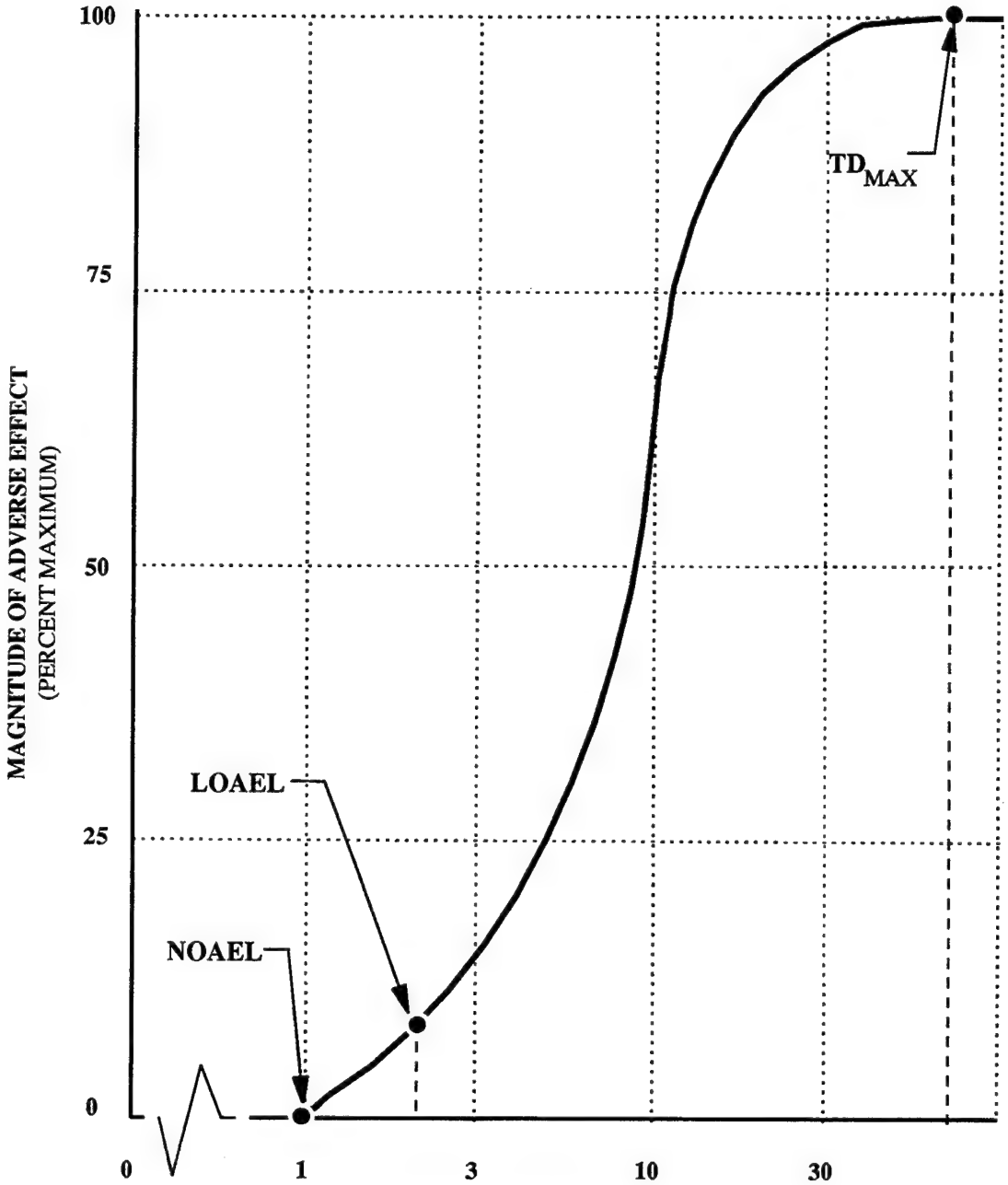
9.3 CANCER SLOPE FACTORS

With the exceptions of lead and parathion, all chemicals detected in the stack gases that are classified as carcinogens by EPA (Groups A, B, or C) and/or the International Agency for Research on Cancer (IARC) (Groups 1, 2A, or 2B) were evaluated for potential carcinogenic risk (CIS, 1988; EPA, 1990). The chemicals that have been categorized as carcinogens and their EPA and IARC carcinogenicity classifications are presented in Table 9-1. (All tables are presented at the end of the section). An explanation of the EPA and IARC carcinogenicity classification systems is presented in Table 9-2.

Even though lead is currently classified as a B2 carcinogen by EPA (1992), a carcinogenic slope factor has not been assigned (EPA, 1992; IRIS, 1993). Lead is not judged to be a potent carcinogen and the evidence is currently being evaluated by EPA. Therefore, lead has not been evaluated for carcinogenic risk in this risk assessment. However, EPA Region VIII has requested that lead be evaluated by comparing predicted soil and air concentrations to soil cleanup levels and National Ambient Air Quality Standards (NAAQS). This comparison can be found in Section 10 of this document.

9.3.1 Oral Route

The carcinogenic potency of a chemical depends on its route of entry into the body. In some cases, a carcinogen may produce tumors only at or near a specific natural route of



KEY:

NOAEL = No-observed-adverse-effect level for critical target organ

LOAEL = Lowest-observed-adverse-effect level for critical target organ

TD_{MAX} = Dose at which toxic response is maximum

***DOSE =** Usually expressed in mg chemical per Kg bodyweight of test animal

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FIGURE 9-2 HYPOTHETICAL DOSE-RESPONSE CURVE FOR A "THRESHOLD" OR NONCARCINOGENIC CHEMICAL

entry (e.g., nasal passages) and may not be carcinogenic through other exposure routes. This applies to several of the evaluated inorganic pollutants, including cadmium, chromium VI, and nickel (EPA, 1990). Therefore, cancer risk was not calculated for these metals through the oral route. Oral slope factors, expressed in units of $(mg/kg\text{-}day)^{-1}$ and/or unit risk factors, expressed in units of $(\mu g/L)^{-1}$, were available for the remaining evaluated carcinogens. A slope factor was calculated from the unit risk factor in accordance with EPA guidance (EPA, 1990) when a slope factor was unavailable.

9.3.2 Inhalation Route

The carcinogenic potency of inhalation carcinogens can be presented as a slope factor expressed in units of $(mg/kg\text{-}day)^{-1}$, or as a unit risk factor expressed in units of $(\mu g/m^3)^{-1}$. These values can be interconverted in accordance with EPA guidance by assuming the inhalation of 20 m^3 of air/day and a body weight of 70 kg (EPA, 1990). In Section 10, the potency of inhalation carcinogens expressed as the slope factor [i.e., $(mg/kg\text{-}day)^{-1}$] is used in conjunction with the estimated daily intakes, calculated as administered dose, in estimating cancer risk.

Inhalation slope factors were available for some of the carcinogens selected for evaluation (EPA, 1990). For the few organics for which an inhalation slope factor was unavailable, the oral slope factor was used to evaluate the inhalation pathway. For dioxins/furans (as 2,3,7,8-TCDD equivalents) it was necessary to modify the slope factor presented by EPA, and for arsenic it was necessary to recalculate an inhalation slope factor from the unit risk factor.

Both the unit risk factor and slope factor for 2,3,7,8-TCDD were derived by EPA from the oral slope factor. In developing the unit risk factor, EPA has incorporated a factor of 0.75 to account for the fraction of inhaled particles retained in the body. The agency, however, did not adjust the inhalation slope factor (EPA, 1990). Because the fraction of inhaled

particles is not taken into account elsewhere in the report, to be consistent with the approach used in developing the unit risk factor, the inhalation slope factor for 2,3,7,8-TCDD (EPA, 1990) also was adjusted (i.e., multiplied) by a factor of 0.75. This adds an additional level of conservation.

Although an inhalation slope factor was available for arsenic, the factor reflects the potency of the absorbed dose (EPA, 1990). In this evaluation, the dosages that were calculated for the inhalation pathway were expressed as an administered dose. Therefore, an inhalation slope factor for arsenic was derived from the unit risk factor, which expresses the potency of the administered dose.

9.3.3 Dermal Route

Although few data are available concerning the carcinogenic activity of chemicals that are systemically absorbed through the skin, it is assumed that all of the chemicals that are carcinogenic through the oral route are potentially carcinogenic through the dermal route. Those chemicals that are categorized as being carcinogenic through the inhalation route only (i.e., cadmium, chromium, nickel) were not addressed. As discussed in Subsection 9.3.1, these metals cause tumors at the site of exposure (i.e., respiratory tract). There are inadequate data to associate these chemicals with systemic tumors as a result of exposure through other natural exposure routes (i.e., oral or dermal).

In the absence of dermal slope factors for all of the carcinogens, a dermal slope factor was derived for each chemical in accordance with EPA guidance by dividing its respective oral slope factor by an appropriate gastrointestinal absorption factor (EPA, 1989). As a result, each dermal slope factor represents the potency of the absorbed dermal dose. This is consistent with the approach described in Subsection 8.2.3 for calculating intake through dermal exposure in which the estimated daily intake was expressed as an absorbed dermal dose.

Ideally, each oral slope factor should be adjusted by a gastrointestinal absorption factor that corresponds specifically to the test species/strain and the vehicle that were used in the studies on which the oral slope factor was based. These data were either lacking for most of the chemicals or were, at best, limited. Therefore, assumptions were made regarding the gastrointestinal absorption of each of the chemicals, depending on their general chemical classification: volatile organic, semi-volatile organic, or inorganic. The screening process of pollutants from the soil pathway, discussed in Subsection 7.4.2, excludes all volatile organic compounds from evaluation through the dermal route. The assumptions were based on available information for semi-volatiles and inorganics and are expected to be conservative. Gastrointestinal absorption factors of 50% (0.50), and 5% (0.05) were assumed for semi-volatile organics and inorganics, respectively. It should be noted that the lower the gastrointestinal absorption factor, the more conservative the toxicity value becomes.

Oral toxicity values for semi-volatile organics are usually derived from oral studies in which the agent is administered in the diet, by gavage or by capsule. In a few cases, they may also be developed from inhalation data. Semi-volatile organics are also expected to be well absorbed (i.e., 50% or greater). A gastrointestinal absorption factor of 50% was assumed for the semi-volatiles. This value probably best approximates absorption through dietary exposure and is likely to be conservative for the other vehicles (i.e., gavage and capsule). Metals, in general, tend to be poorly absorbed in the gastrointestinal tract. However, absorption is highly dependent on the water and lipid solubility of the specific chemical form(s) in which it is present. An absorption factor of 5% was used for metals. This value corresponds to the default value suggested by EPA for cases in which the gastrointestinal absorption of a substance is not known (EPA, 1989).

9.3.4 Cancer Slope Factors Summary

The slope factors for the carcinogenic pollutants are presented in Table 9-1. The reference or basis for each of the slope factors is indicated.

9.4 REFERENCE DOSES FOR NONCARCINOGENIC EFFECTS

RfDs are developed for specific exposure routes (oral, dermal, inhalation) and also are derived for chronic exposures and subchronic exposures (defined by EPA as 7 years or longer and 2 weeks to 7 years, respectively) (EPA, 1989). In this toxicity assessment, only chronic reference doses were employed because exposure to the individual is assumed to occur over a lifetime. Chronic dermal RfDs were derived using established procedures discussed below. EPA has not yet assigned RfDs for chemicals with the potential for dermal exposures. The RfDs used in this toxicity assessment are discussed, by exposure route, in the subsections that follow. As mentioned in the Introduction to Section 9, original toxicity data from the 1991 risk assessment was used where available.

A reference dose for lead has not been approved by EPA (IRIS, 1991 and 1993); therefore, a noncarcinogenic hazard quotient was not calculated. EPA Region VIII (Weis, 1991) recommended that comparison be made of predicted soil and air concentrations to soil cleanup and air standards, respectively. Refer to Section 10 for this comparison.

9.4.1 Oral Route

Establishing oral RfDs was a step-by-step process based on establishing a hierarchy for the available information as follows:

1. The Integrated Risk Information System (IRIS, 1991) computer database was searched for each chemical. All reported RfDs found were used since these are the most current EPA-approved RfDs.

2. If RfDs were not available on IRIS, the Health Effects Assessment Summary Tables (HEAST) (EPA, 1990) were consulted for each chemical. If a RfD

was located, it was used because these numbers have been established by EPA's Environmental Criteria and Assessment Office specifically for use in risk assessments under CERCLA and RCRA.

3. When RfDs were not available through the EPA sources listed above, several recent risk assessment documents written for the on-post and off-post operable units of the RMA (Ebasco, 1990; ESE et al., 1989) were consulted. RfDs had previously been derived for some chemicals not available in the EPA databases/documents. As these RfDs were already approved in these projects by the Region VIII EPA, they were used where appropriate.

4. If an RfD was available for a structurally related compound, it was used.

5. All other RfDs were derived by WESTON's toxicologists. See Appendix 9-A for the RfD derivations.

9.4.2 Inhalation Route

As for the oral route, establishing inhalation RfDs was a step-by-step process based on developing a hierarchy for the available information as follows:

1. The Integrated Risk Information System (IRIS, 1991) computer database was searched for each chemical. All RfDs found were used because these are the most current EPA-approved RfDs.

2. If RfDs were not available on IRIS, the HEAST (EPA, 1990) were consulted for each chemical. If a RfD was found, it was used since these numbers have been established by EPA's Environmental Criteria and Assessment Office specifically for risk assessments under CERCLA and RCRA sites. On

occasion, a HEAST value was presented in mg/m^3. The following equation was used to convert the value to mg/kg-day (EPA, 1989):

$$\text{RfD (mg/kg-day)} = \frac{\text{RfD (mg/m}^3\text{) x 20 (m}^3\text{/day)}}{\text{70 (kg)}}$$

3. When the RfDs were not available through EPA sources, several recent risk assessment documents written for the on-post and off-post operable units of the RMA (Ebasco, 1990; ESE et al., 1989) were consulted. RfDs had previously been derived for some chemicals not available in the EPA databases/documents. As these RfDs were already approved by the EPA, they were used as reference doses where appropriate.

4. If an annual National Ambient Air Quality Standard (NAAQS) was available for a pollutant, it was converted into a RfD using the equation above.

5. Occupational Exposure Limits (OELs) were used next to calculate inhalation RfDs, as described in Subsection 9.4.2.1. The OELs that were considered included the American Conference of Governmental Industrial Hygienists Threshold Limit Values (TLVs) (ACGIH, 1989), the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs) (DOL, 1989) and the National Institute for Occupational Safety and Health (NIOSH) Recommended Exposure Limit (RELs) (CDC, 1988).

6. If both a short-term NAAQS and an OEL were available for a chemical, the most conservative derived inhalation RfD was used.

7. For the remaining organic pollutants, the chronic oral RfD was used, by default, as the chronic inhalation RfD.

9.4.2.1 The Use of OELs and NAAQSs for Calculating Inhalation RfDs

It is recognized that there are several factors that limit the usefulness of occupational guidelines in the derivation of RfDs. OELs are intended to protect healthy workers from adverse health effects when exposed to a chemical in the workplace over a 40-hour work week. Inhalation RfDs are intended to protect the general population, including sensitive subpopulations, based on a continuous exposure. Furthermore, OELs are derived by consensus as opposed to a procedure that incorporates standard uncertainty factors according to the nature of the toxicological database from which the RfD is derived. OELs also may be based on toxic endpoints other than chronic noncarcinogenic health effects (e.g., irritation and odor).

In consideration of the limitations of the OELs, an equation was developed to derive inhalation RfDs from OELs, incorporating uncertainty factors to account for potential continuity of exposure and variability in human sensitivity. In addition, the data and/or toxic endpoint for each of the applicable OELs were reviewed to ensure that the OEL was suitable to serve as the basis for a chronic inhalation RfD (ACGIH, 1986; CDC, 1988; DOL, 1989). For each chemical, the most conservative OEL that has been developed, and which is based on, or protective against, noncarcinogenic effects, was used to derive the inhalation RfD. The equation and assumptions that were used to calculate inhalation RfDs from OELs are presented in Table 9-3. The approach is consistent with EPA guidelines for deriving an RfD from a NOAEL (EPA, 1989). The equation calculates a daily dose to an exposed worker, normalized over a 7-day exposure period (i.e., the NOAEL), and adjusts the dose by an uncertainty factor of 10 to take into account human variability and a modifying factor of 10 to account for continuous daily exposure.

NAAQSs include primary standards, which are ambient air quality standards that are judged to be protective of public health with an adequate margin of safety, and secondary standards, which are intended to protect the public welfare from any adverse effects (EPA,

1987). If an annual average NAAQS was available for a pollutant, it was used in preference to an OEL as a basis for the inhalation RfD, because an annual average NAAQS is developed to protect the general population, not just workers, over a long-term exposure period. Subsequently, the inhalation RfD for particulate matter was calculated from the respective NAAQS expressed as an annual arithmetic mean, assuming an inhalation rate of 20 m^3/day and a body weight of 70 kg. If only a short-term (i.e., less than annual) NAAQS was available, RfDs were derived using both the short-term value and the OEL, and the most conservative value was used.

9.4.2.2 Adjustments to Inhalation RfDs

In the absence of an OEL or an NAAQS for dioxins/furans, the oral RfD for dioxins/furans (see Subsection 9.4.2) was used as the basis for the inhalation RfD. As previously discussed in Subsection 9.3.1, EPA (1989) has similarly based the inhalation potency factor for 2,3,7,8-TCDD on the oral potency factor, indicating that its toxicity is presumed to be the same through both the oral and inhalation routes. Comparable to the approach used in deriving the inhalation potency factor, the inhalation RfD was adjusted for the fraction of inhaled particles that are retained in the lung by dividing the oral RfD by 75 percent.

9.4.3 Dermal Route

No RfDs have been developed by EPA for the dermal route. Therefore, dermal RfDs were derived for the chemicals of concern in accordance with EPA guidelines (EPA, 1989). Chronic dermal RfDs were derived by multiplying the values used as the chronic oral RfDs by appropriate gastrointestinal absorption factors. The absorption factors that were used in deriving the dermal RfDs were the same as those used in deriving the dermal slope factors (see Subsection 9.3.3). Gastrointestinal absorption factors of 50% (0.50), and 5% (0.05) were assumed for semi-volatile organics and inorganics, respectively.

The RfDs that were used in the evaluation of noncarcinogenic risk are presented in Table 9-4. The source or basis of each of the RfDs is also indicated.

9.4.4 Reference Doses Summary

This section presents the sources of information and methods used to determine chronic toxicity criteria for carcinogens and noncarcinogens. Tables 9-1 and 9-4 summarize the carcinogenic slope factors and reference doses for noncarcinogenic effects, respectively. As there were a number of chemicals for which EPA has not derived reference doses by certain routes of exposure, detailed discussions of the toxicity studies and uncertainty factors applied to derive the RfDs were presented in this section and in Appendices 9A and 9B.

SECTION 9

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Table 9-1

Slope Factors for Carcinogenic Health Effects (mg/kg-day)$^{-1}$

Pollutant	EPA Carcinogenicity Classification	IARC Carcinogenicity Classification	Inhalation Slope Factor	Reference or Basis of Inhalation Slope Factor	Oral Slope Factor	Reference or Basis of Oral Slope Factor	Dermal Slope Factor
Organics							
Benzene	A	1	2.90E-02	IRIS, 1990	2.90E-02	IRIS, 1990	NC (v)
Bis(2-ethylhexyl)phthalate	B2	NL	1.4E-02	OSF	1.4E-02	IRIS, 1993	2.80E-02(sv)
Bromodichloromethane	B2	NL	6.20E-02	OSF	6.20E-02	IRIS, 1993	NC (v)
Carbon Tetrachloride	B2	2B	1.30E-01	IRIS, 1990	1.30E-01	IRIS, 1990	NC (v)
Chloroform	B2	2B	8.10E-02	IRIS, 1990	6.10E-03	IRIS, 1990	NC (v)
Dibromochloromethane	C	NL	8.40E-02	OSF	8.40E-02	IRIS, 1993	1.68E-01 (sv)
Dioxins/Furans (as 2,3,7,8 TCDD)	B2	2B	1.13E+05[a]	EPA, 1990	1.50E+05	EPA, 1990	3.00E+05 (sv)
Heptachlor epoxide	B2	NL	9.10E+00	IRIS, 1993	9.10E+00	IRIS, 1993	1.82E+01
Methyl Chloride	C	3	6.30E-03	EPA, 1990	1.30E-02	EPA, 1990	NC (v)
Methylene Chloride	B2	2B	1.40E-02	EPA, 1990	7.50E-03	EPA, 1990	NC (v)
Styrene	B2	2B	2.00E-03	EPA, 1990	3.00E-02	EPA, 1990	NC (v)
Inorganics							
Arsenic	A	1	1.50E+0[b]	IRIS, 1990	1.75E+00	EPA, 1990	3.50E+01 (i)
Cadmium	B[c]	2A	6.10E+00	IRIS, 1990	NC	---	NC (i)

Table 9-1
Slope Factors for Carcinogenic Health Effects $(mg/kg/day)^{-1}$
(continued)

Pollutant	EPA Carcinogenicity Classification	IARC Carcinogenicity Classification	Inhalation Slope Factor	Reference or Basis of Inhalation Slope Factor	Oral Slope Factor	Reference or Basis of Oral Slope Factor	Dermal Slope Factor
Chromium (VI)	A[c]	1	4.10E+01	IRIS, 1990	NC	---	NC (i)
Nickel (as soluble salts)	A[c]	1	2.00E-02	IRIS, 1990	NC	---	NC (i)

Footnotes:

NC = Not a carcinogenic concern through the oral and dermal routes of exposure (see Subsection 9.3.1 for further information).
NL = Not listed.
OSF = Oral Slope Factor.
- Substance was treated as a volatile (v), semi-volatile (sv), or an inorganic (i) in deriving the dermal slope factor.
[a] Based on a slope factor of 1.56E+05 $(mg/kg\text{-}day)^{-1}$, adjusted for 0.75 inhalation retention.
[b] Calculated from a proposed unit risk, as $(ug/L)^{-1}$, assuming the ingestion of 2 liters of water/day and a body weight of 70 kg.
[c] Classification is for the inhalation route only.

Table 9-2

EPA and IARC Categorizations of Carcinogens Based on Human and Animal Evidence

EPA Categorization of Carcinogens (EPA, 1986b)					
	Animal Evidence				
	Sufficient	Limited	Inadequate	No Data	No Evidence
Human Evidence					
Sufficient	A	A	A	A	A
Limited	B1	B1	B1	B1	B1
Inadequate	B2	C	D	D	D
No data	B2	C	D	D	E
No evidence	B2	C	D	D	E

Key:

Group A - Human carcinogen (sufficient evidence from epidemiological studies).

Group B1 - Probable human carcinogen (at least limited evidence of carcinogenicity to humans).

Group B2 - Probable human carcinogen (a combination of sufficient evidence in animals and inadequate data in humans).

Group C - Possible human carcinogen (limited evidence in animals in the absence of human data).

Group D - Not classified (inadequate animal and human data).

Group E - No evidence for carcinogenicity (no evidence for carcinogenicity in at least two adequate animal tests in different species, or in both epidemiological and animal studies).

Table 9-2 (cont'd.)

EPA and IARC Categorizations of Carcinogens Based on Human and Animal Evidence

IARC Categorization of Carcinogens (WHO, 1987)

Group 1 - Human carcinogen (sufficient evidence of carcinogenicity in humans).

Group 2A - Probable human carcinogen (limited evidence of carcinogenicity in humans and sufficient evidence of carcinogenicity in experimental animals).

Group 2B - Possible human carcinogen (limited evidence of carcinogenicity in humans and insufficient evidence of carcinogenicity in experimental animals; insufficient evidence of carcinogenicity in humans and sufficient evidence of carcinogenicity in experimental animals; or insufficient evidence of carcinogenicity in humans and limited evidence of carcinogenicity in experimental animals, with supporting evidence from other relevant data).

Group 3 - Not classifiable (substances in this category do not fall into any other category).

Group 4 - Probably not carcinogenic to humans.

Table 9-3

Approach to Deriving an Inhalation Reference Dose (RfD) from an Occupational Exposure Limit (OEL)

$$\text{Inhalation RfD (mg/kg-day)} = \frac{\text{OEL (mg/m}^3\text{)} \times \text{Air breathed per work day (m}^3\text{/day)} \times \text{Work week adjustment factor}}{\text{Body weight (kg)} \times \text{Uncertainty factor}}$$

Where:

Inhalation RfD	=	Inhalation reference dose.
OEL	=	Occupational exposure limit.
Air breathed per work day	=	10 cu m. This value has been used by EPA when deriving an inhalation-acceptable chronic intake (AIC) for the public from worker exposure levels (EPA, 1984b).
Work week adjustment factor	=	5 days/7 days. Because the OEL is based on a 5-day work week, an adjustment was made to average the dose over a 7-day week.
Body weight	=	70 kg (weight of an average adult) (EPA, 1989).
Uncertainty factor	=	100. A factor of 10 is recommended by the EPA when deriving RfDs from human data to account for human variation (i.e., to protect sensitive members of the general population (e.g., children and the elderly) (EPA, 1989). An additional modifying factor of 10 was included to take into account a continuous exposure for a resident (versus an intermittent exposure for a worker) and a lifetime exposure for a resident (versus a less than lifetime exposure for a worker). Uncertainty factors of 10 to 100 are commonly used by government agencies when deriving public health criteria from OELs (EPA, 1984b; MDNR, 1989; PAMS, 1983).

Table 9-4

Reference Doses (RfDs) for Noncarcinogenic Health Effects (mg/kg-day)

Pollutant	Inhalation RfD	Reference or Basis of Inhalation RfD	Oral RfD	Reference or Basis of Oral RfD	Dermal RfD
Organics					
Benzene	3.26E-02	ACGIH-TWA 1989-90	1.00E-03	Derived	NC (v)
Benzoic Acid	4.00E+00	Oral RfD	4.00E+00	IRIS, 1990	2.00E+00 (sv)
Bis(2-ethylhexyl)phthalate	5.10E-03	ACGIH-TWA 1992-93	2.00E-02	IRIS, 1993	1.00E-02 (sv)
Bromodichloromethane	2.00E-02	Oral RfD	2.00E-02	IRIS, 1993	NC (v)
Butylbenzyl phthalate	2.00E-01	Oral RfD	2.00E-01	IRIS, 1993	1.00E-01 (sv)
Carbon Tetrachloride	3.16E-02	ACGIH-TWA 1989-90	7.00E-04	IRIS, 1990	NC (v)
Chlorobenzene	5.00E-03	EPA, 1990	2.00E-02	IRIS, 1990	NC (v)
Chloroform	5.00E-02	ACGIH-TWA 1989-90	1.00E-02	IRIS, 1990	NC (v)
Dibromochloromethane	2.00E-02	Oral-RfD	2.00E-02	IRIS, 1993	1.00E-02 (sv)
Di-n-butylphthalate	1.00E-01	Oral RfD	1.00E-01	IRIS, 1993	5.00E-02 (sv)
Diethylphthalate	5.10E-03	ACGIH-TWA, 1992-93	8.00E-01	IRIS, 1993	4.00E-01
Dimethylphthalate	5.10E-03	ACGIH-TWA, 1992-93	1.00E+01	IRIS, 1993	5.00E+00
Dioxins/Furans (as 2,3,7,8 TCDD)	1.00E-09	Oral RfD	1.00E-09	ATSDR, 1989	5.00E-10 (sv)

Table 9-4
Reference Doses (RfDs) for Noncarcinogenic Health Effects (mg/kg/day) (continued)

Pollutant	Inhalation RfD	Reference or Basis of Inhalation RfD	Oral RfD	Reference or Basis of Oral RfD	Dermal RfD
Heptachlor epoxide	1.30E-05	Oral RfD	1.30E-05	IRIS, 1993	6.50E-06 (sv)
Methyl Chloride	1.05E-01	ACGIH-TWA 1989-90	1.80E-02	Derived	NC (v)
Methylene Chloride	8.57E-01	EPA, 1990	6.00E-02	EPA, 1990	NC (v)
Styrene	2.17E-01	ACGIH-TWA	2.00E-01	IRIS, 1990	NC (v)
Toluene	5.71E-01	EPA, 1990	2.00E-01	IRIS, 1990	NC (v)
Xylenes (total)	8.57E-02	EPA, 1990	2.00E+00	EPA, 1990	NC (v)
Inorganics					
Aluminum	2.04E-03[a]	ACGIH-TWA 1989-90	ND	---	NC (i)
Antimony	5.10E-04	ACGIH-TWA 1989-90	4.00E-04	IRIS, 1990	2.00E-05 (i)
Arsenic	2.04E-04	ACGIH-TWA 1989-90	1.00E-03	EPA, 1990	5.00E-05 (i)
Barium	1.00E-04	EPA, 1990	ND	---	NC (i)
Boron	4.11E-03[b]	ACGIH-TWA 1989-90	ND	---	NC (i)
Cadmium	5.10E-05	ACGIH-TWA 1989-90	1.00E-03	IRIS, 1990	5.00E-05 (i)
Calcium	1.46E-03[c]	ACGIH-TWA 1989-90	ND	---	NC (i)

Table 9-4
Reference Doses (RfDs) for Noncarcinogenic Health Effects (mg/kg/day)
(continued)

Pollutant	Inhalation RfD	Reference or Basis of Inhalation RfD	Oral RfD	Reference or Basis of Oral RfD	Dermal RfD
Chromium (III)	5.10E-04	ACGIH-TWA 1989-90	ND	---	NC (i)
Chromium (VI)	5.10E-05	ACGIH-TWA 1989-90	ND	---	NC (i)
Copper	1.00E-02	EBASCO, 1990	3.80E-02	Ebasco, 1990	1.90E-03 (i)
Iron	1.02E-03[d]	ACGIH-TWA 1989-90	ND	---	NC (i)
Manganese	3.00E-04	EPA, 1990	ND	---	NC (i)
Mercury	8.57E-05	EPA, 1990	3.00E-04	EPA, 1990	1.50E-05 (i)
Molybdenum	5.10E-03[e]	ACGIH-TWA 1989-90	ND	---	NC (i)
Nickel	1.02E-04[f]	ACGIH-TWA 1989-90	ND	---	NC (i)
Silver	1.02E-05[g]	ACGIH-TWA 1989-90	ND	---	NC (i)
Tin	2.04E-03	ACGIH-TWA 1989-90	ND	---	NC (i)
Titanium	6.11E-03[h]	ACGIH-TWA 1989-90	ND	---	NC (i)
Vanadium	5.10E-05	ACGIH-TWA 1989-90	7.00E-03	EPA, 1990	NC (i)
Zinc	8.19E-03[i]	ACGIH-TWA 1989-90	2.00E-01	EPA, 1990	NC (i)

Table 9-4
Reference Doses (RfDs) for Noncarcinogenic Health Effects (mg/kg/day)
(continued)

Pollutant	Inhalation RfD	Reference or Basis of Inhalation RfD	Oral RfD	Reference or Basis of Oral RfD	Dermal RfD
Other Acid Gases/ Criteria Pollutants					
Carbon Monoxide	4.08E-02	ACGIH-TWA 1989-90	NC	---	NC
Hydrogen Chloride	7.65E-03	ACGIH-TWA 1989-90	NC	---	NC
Hydrogen Fluoride	2.65E-02	ACGIH-TWA 1989-90	NC	---	NC
Nitrogen Oxides	2.86E-02	ACGIH-TWA 1989-90	NC	---	NC
Nitric Acid	5.30E-03	ACGIH-TWA 1989-90	NC	---	NC
Sulfur Dioxide	2.29E-02	ACGIH-TWA 1989-90	NC	---	NC
Sulfuric Acid Mist	1.02E-03	ACGIH-TWA 1989-90	NC	---	NC
Particulate Matter	4.29E-02	NAAQS	NC	---	NC

Table 9-4
Reference Doses (RfDs) for Noncarcinogenic Health Effects (mg/kg/day)
(continued)

Footnotes:

ACGIH-TWA = American Conference of Governmental Industrial Hygienists. Time-Weighted Average.
NAAQS = National Ambient Air Quality Standard.
NC = Not of concern through this exposure route (see Section 8).
ND = Not evaluated due to lack of data.

(i) Substance was treated as an inorganic (i) in deriving the dermal reference dose.
(sv) Substance was treated as a semi-volatile (sv) in deriving the dermal reference dose.
(v) Substance was treated as a volatile (v) in deriving the dermal reference dose.
[a] Converted from TLV for soluble salts as aluminum.
[b] Converted from TLV for boron oxide and converted to "as boron."
[c] Converted from TLV for calcium oxide and converted to "as calcium."
[d] Converted from TLV for soluble salts as iron, the most conservative value for inorganic iron.
[e] Converted from TLV for soluble compounds as molybdenum, the most conservative value.
[f] Converted from TLV for soluble compounds as nickel, the most conservative value.
[g] Converted from TLV for soluble compounds as silver, the most conservative value.
[h] Converted from TLV for titanium dioxide and converted to "as titanium."
[i] Converted from TLV for zinc oxide dust rather than fume and converted to "as zinc."

SECTION 10

RISK CHARACTERIZATION

In this section, both carcinogenic and noncarcinogenic risks were evaluated using the daily pollutant intakes calculated in Section 8 and the toxicity values presented in Section 9. The total excess lifetime carcinogenic risk was calculated based on a combination of adult, child, and infant exposures for the Resident-A, Resident-B, and Farmer scenarios. The noncarcinogenic risks for these scenarios were evaluated individually for adult, child, and infant exposures. The Worker scenario evaluated carcinogenic and noncarcinogenic risks only for an adult.

10.1 DETERMINATION OF CARCINOGENIC RISK

Carcinogenic risk was calculated for each carcinogen through each exposure pathway for each maximally exposed individual. An individual's total excess lifetime carcinogenic risk in any given exposure scenario was defined as the sum of adult, child, and infant risks, each of which was appropriately adjusted for exposure duration. Calculation of total carcinogenic risk allows for an evaluation of overall potential risk as well as pinpointing those exposure routes and specific pollutants that result in the highest relative risks. Carcinogenic risk was calculated for each route of exposure using the following formula:

$$\text{Risk} = \text{Intake} \times \text{CSF} \times \text{EDA}$$

Where:

Risk	=	Excess lifetime carcinogenic risk
Intake	=	Average estimated daily intake (mg/kg-day)
CSF	=	Carcinogenic slope factor $(\text{mg/kg-day})^{-1}$
EDA	=	Exposure duration adjustment

The carcinogenic slope factors for the inhalation, oral, and dermal routes of exposure were presented previously in Table 9-3. The estimated daily intakes were previously determined for the appropriate routes of exposure in Section 8. The estimated daily intakes and exposure duration adjustments used for the adult, child, and infant are discussed in the subsections that follow. The exposure duration adjustment compensates for exposure periods of less than 70 years. Carcinogenic risks were based upon average estimated daily intakes, which were derived from soil concentrations averaged over a 70-year lifetime.

10.1.1 Adult Carcinogenic Risk

As presented in the previous equation, the carcinogenic risk resulting from exposure to a particular chemical is dependent on three factors: dosage, carcinogenic potency of the chemical, and exposure duration. Adult doses were summarized previously at the end of Section 8. Average doses were used in determining carcinogenic risk for the adult, since carcinogenic risk is based on exposure over 70 years (average lifetime exposure), the majority of which occurs as an adult. The length of exposure also is taken into account in the calculation of risk, since carcinogenic potency factors are based on an exposure duration of 70 years, and carcinogenic risk is assumed to be proportional to exposure duration.

For the Resident-A, Resident-B, and Farmer exposure scenarios, carcinogenic risk was calculated for the ingestion and dermal routes of exposure based on 1 year of exposure as an infant, 5 years of exposure as a child, and 64 years of exposure as an adult; therefore, an exposure duration adjustment of 64/70 years was used to calculate adult carcinogenic risk for these exposure routes. For the inhalation route of exposure, only 2 years of exposure (i.e., the facility lifetime) could occur over an individual's lifetime. Since children and infants have higher exposure rates per unit body weight than adults, the maximum exposed individual was conservatively assumed to be in these age groups. It therefore was assumed that over a lifetime, 1 year of pollutant inhalation occurred as an infant, 1 year as a child, and no inhalation exposure occurred as an adult. Carcinogenic risk from inhalation exposure as an adult was evaluated separately and is presented in Subsection 10.1.5.

For the Worker scenario, exposure was assumed to occur over 30 years (Ebasco, 1990), resulting in an exposure duration adjustment of 30/70 years for the ingestion and dermal routes of exposure. For worker inhalation exposure, an exposure duration adjustment of 2/70 years was used, based on the planned operation of the SQI.

The calculated carcinogenic risks based on exposure as an adult through all routes of exposure are presented in Appendix 8H, Tables 8H-1 through 8H-4.

10.1.2 Child Carcinogenic Risk

The predicted childhood doses for the applicable carcinogens were summarized previously at the end of Section 8. As with the adult, average doses were used in determining carcinogenic risk. The childhood exposure duration was assumed to be 5 years, based on the exposure scenario described in Subsection 8.3. Therefore, an exposure duration adjustment of 5/70 was used for childhood risk calculations for the ingestion and dermal exposure routes. As discussed in Subsection 10.1.1, a child was assumed to be exposed to pollutants through the inhalation route for 1 year based on overall lifetime exposure; therefore, an exposure duration of 1/70 was used for the inhalation route. Carcinogenic risk estimates based on exposure as a child for each route of exposure are summarized in Appendix 8H, Tables 8H-5 through 8H-7.

10.1.3 Infant Carcinogenic Risk

Infants may be exposed to SQI-related pollutants through the ingestion of mother's milk and through the inhalation pathway. The predicted infant doses for the applicable carcinogens were summarized previously at the end of Section 8. An infant was assumed to be exposed for 1 year based on the exposure scenario described in Subsection 8.3.4; therefore, an exposure duration adjustment of 1/70 was used in calculating carcinogenic risk. In order to prevent underestimation of carcinogenic risk to the infant, maximum daily intakes determined for the mother were used instead of average lifetime daily intakes in calculating

breast milk concentrations. Tables 8H-8 and 8H-10 (Appendix 8H) present the estimates of carcinogenic risk based on inhalation exposure and mother's milk ingestion for all of the applicable exposure scenarios.

10.1.4 Total Carcinogenic Risk

The total carcinogenic risk for each exposed population was calculated by summing the individual risks calculated based on exposure as an adult, child, and infant. As previously stated, the Worker scenario was evaluated only for an adult. The results are shown in Tables 10-1 through 10-4 for the Resident-A, Resident-B, Farmer, and Worker scenarios, respectively. (All tables are presented at the end of this section.) The following equation was used to calculate total risk for each scenario:

$$Risk_{total} = Risk_{inhl} + Risk_{ing} + Risk_{der}$$

Where:

$Risk_{total}$ = Total lifetime carcinogenic risk

$Risk_{inhl}$ = Childhood and infant carcinogenic risk (Resident-A, Resident-B, and Farmer scenarios), or adult carcinogenic risk (Worker scenario) associated with the inhalation route of exposure

$Risk_{ing}$ = Adult, childhood, and infant carcinogenic risk (Resident-A, Resident-B, and Farmer scenarios) or adult carcinogenic risk (Worker scenario) associated with the ingestion route of exposure

$Risk_{der}$ = Adult and childhood carcinogenic risk (Resident-A, Resident-B, and Farmer scenarios) or adult carcinogenic risk (Worker scenario) associated with the dermal route of exposure

10.1.5 Adult Inhalation Carcinogenic Risk in Off-Site Exposure Scenarios

Adult inhalation carcinogenic risk was not addressed in the off-site exposure scenarios (Resident-A, Resident-B, and Farmer) for the technical reasons previously cited in

Subsection 10.1.1. Inhalation cancer risks were calculated separately for the adult using the same exposure assumptions, modeling parameters, and toxicity criteria used in the estimation of inhalation carcinogenic risk for children and infants in the three off-site scenarios. This was done to insure that adults would not be at risk through the inhalation pathway. The results are presented in Table 10-17, and they are discussed in detail in subsection 10.3.1.

10.2 DETERMINATION OF NONCARCINOGENIC RISK

In this subsection, noncarcinogenic risks were evaluated by comparing predicted maximum daily intakes to reference doses (RfDs). This was accomplished by the calculation of hazard quotients and hazard indices. A hazard quotient for a particular pollutant through a given exposure route is the ratio between the predicted daily intake and the applicable RfD, as shown in the following equation:

$$HQ = Intake/RfD$$

Where:

HQ	=	Hazard quotient
Intake	=	Maximum estimated daily intake (mg/kg-day)
RfD	=	Reference dose (mg/kg-day)

Maximum estimated daily intakes were based on maximum soil concentrations achieved over the 2-year facility lifetime.

A total exposure hazard index (HI) was calculated for the adult, child, and infant in each scenario (except the worker, which is adult only) by summing the hazard quotients for all pollutants through all exposure routes. It is important to note that this methodology, unlike that used in the evaluation of carcinogenic risk, is not a measure of and cannot be used to quantify risk (i.e., it does not predict the relative likelihood or probability of the occurrence of adverse effects). If a hazard quotient or hazard index exceeds 1, it simply indicates that

there is a potential for noncarcinogenic health effects to occur under the defined exposure conditions. Because RfDs incorporate a margin of uncertainty, exceedance of a criterion does not necessarily indicate that an adverse effect will occur. It also should be noted that, unlike the estimation of carcinogenic risk, the evaluation of noncarcinogenic risk does not involve an adjustment for the number of years of exposure. It is assumed that any chronic exposure, regardless of the duration, might potentially result in adverse effects if the RfD is exceeded in a given period of an individual's life (e.g., infancy, childhood, or adulthood). RfDs were presented previously in Table 9-4. All pollutants, both carcinogens and noncarcinogens, were evaluated for potential noncarcinogenic effects.

10.2.1 Adult Noncarcinogenic Risk

The maximum estimated daily intakes for the pollutants of concern used in the evaluation of noncarcinogenic risk were presented in Subsection 8.2. Adult hazard quotients were calculated for the inhalation, ingestion, and dermal routes of exposure. These hazard quotients and the respective hazard indices are presented in Tables 10-5 through 10-8 for the Resident-A, Resident-B, Farmer, and Worker adult scenarios, respectively.

10.2.2 Child and Infant Noncarcinogenic Risk

Noncarcinogenic risk for the child and infant was evaluated by the same method used for the adult. Predicted maximum estimated daily intakes for children and infants were presented in Subsection 8.3. Hazard quotients were calculated for the inhalation, ingestion, and dermal routes of exposure for children. These hazard quotients and the respective hazard indices are presented in Tables 10-9 through 10-11 for the child and in Tables 10-12 through 10-14 for the infant, based on the Resident-A, Resident-B, and Farmer scenarios, respectively.

10.3 RESULTS

10.3.1 Carcinogenic Risk

10.3.1.1 Potential Risks From Chemicals That Were Detected

The total lifetime carcinogenic risk was based on exposure as an infant, child, and adult and was estimated to be 9.8E-09 for Resident-A, 6.5E-09 for Resident-B, 3.1E-08 for the Farmer, and 3.8E-10 for the Worker. The individual risk estimates (by chemical and by route of exposure) are presented in Tables 10-1 (Resident-A), 10-2 (Resident-B), 10-3 (Farmer), and 10-4 (Worker).

Table 10-5 presents the cancer risk for each of these populations by pathway as a percentage of total risk. The Farmer scenario showed the highest total cancer risk, with BEHP through the vegetable ingestion pathway accounting for 88.3 percent (2.71E-08) of the total (3.1E-08) (Tables 10-1, 10-5). As discussed in the uncertainty analysis (Section 11), the presence of all phthalates, including BEHP, likely reflected blank contamination. If the risk from BEHP is subtracted, the total cancer risk through the Farmer scenario would be 3.3E-09.

In all other scenarios, inhalation of carcinogenic metals accounted for the majority of cancer risk. Resident A had the highest inhalation risk of all scenarios at 6.6E-09 which represented 67 percent of the total (9.8E-09) (Table 10-5). In all scenarios, arsenic represented the highest percentage of each total inhalation cancer risk (Tables 10-1 through 10-4). Cadmium and chromium VI were the next highest contributors.

In summary, total lifetime cancer risks calculated for each scenario were several orders of magnitude less than the benchmark criteria of 1E-06 (Woodward-Clyde, 1990). As a result, even those chemicals and pathways that were the largest contributors to total risk (e.g., BEHP by vegetable ingestion in the Farmer scenario) do not represent a significant concern. In general, indirect pathways of exposure through soil or surface water contamination played a relatively minor role. Inhalation risk presented the greatest risk overall, but again, total risk was well below the benchmark of concern.

The maximum adult inhalation carcinogenic risk (that the Resident A scenario) was 3.5E-09 (Table 10-6). This cancer risk is more than 2 orders of magnitude below the benchmark risk level of 1E-06 defined in the *Final Decision Document* (Woodward-Clyde, 1990). These cancer risks reflect an adjusted two-year daily exposure based on the operational lifetime of the SQI. Even if these risks were to be added to the total lifetime cancer risks calculated under the assumptions of the original scenarios - a very conservative assumption - the resultant total risks would still be less than the level of concern.

10.3.1.2 Potential Cancer Risk From Chemicals That Were Analyzed For But Not Detected

Table 10-7 presents the potential cancer risk for those chemicals identified as potential release products but which could not be detected in any sample. The cancer risk is based on the risk at the detection limit and therefore shows that maximum lifetime cancer risk from these chemicals could be no greater than 2.55E-07. Because it is extremely unlikely that all of these chemicals would be present at concentrations just below their detection limits, the true cancer risk contributed by this group is likely to be much lower.

10.3.1.3 Potential Cancer Risk From Chemicals Not Analyzed For in the Trial Burn

As noted in Section 4, some chemicals identified as potential release products could not be analyzed in the trial burn due to methodological limitations. As shown in Table 10-8, only one of these chemicals (acrylonitrile) is carcinogenic, and the maximum cancer risk from this chemical, based on the predicted emissions rate, is 1.6E-14 (WESTON, 1991). Thus, even if this chemical were present, it would not significantly increase the estimated excess cancer risk.

10.3.2 Noncarcinogenic Risk

10.3.2.1 Potential Noncancer Hazard Index From Chemicals Detected

The total hazard index for each exposure scenario under trial burn emission conditions was calculated by summing the respective hazard quotients for all chemicals and exposure routes for each exposed individual (adult, child, infant). Note that some gases (carbon monoxide, NO_x, and sulfur dioxide) were measured by continuous emissions monitoring (CEM) during the trial burn.

Adult hazard quotients for each chemical and exposure route are presented in Tables 10-9 (Resident-A), 10-10 (Resident-B), 10-11 (Farmer), and 10-12 (Worker). Child hazard quotients are presented in Tables 10-13 (Resident-A), 10-14 (Resident-B), and 10-15 (Farmer). Respective infant hazard quotients are summarized in Tables 10-16 through 10-18.

Hazard indices for all populations are summarized in Table 10-19. As the table shows, HI values for adults, children, and infants were well below unity in each of the four scenarios. In all scenarios, exposure of the reasonable maximum exposed infant, child, or adult to any single chemical resulted in a range of hazard quotients of between 8.7E-04 and 1.9E-02, a range of hazard indices of between 52 and 1,150 times less than the benchmark level of 1E+00. Therefore, under operating conditions, noncancer health effects are not anticipated from the emitted chemicals in any of the potential populations.

10.3.2.2 Potential Noncancer Hazard Index From Chemicals That Were Analyzed For But Not Detected

Table 10-20 presents the potential noncancer risk for those chemicals which were identified as potential release products (WESTON, 1991), but could not be detected in any sample during the trial burn. Risk is based on the hazard quotient at the detection limit and therefore shows that the maximum noncancer hazard index would be 4.71E-03. Since none

of these chemicals were detected, the noncancer hazard index is likely to be significantly less.

10.3.2.3 Potential Noncancer Hazard Index For Chemicals Not Measured in the Trial Burn

In Section 4, it was discussed that there were a number of chemicals which could not be analyzed in the trial burn although they were identified as potential release products in the 1991 evaluation (WESTON, 1991). Noncancer hazard quotients for all chemicals based on their predicted emission rates for the Resident-A child (the highest noncancer risk), as determined in the 1991 report, were totaled for these chemicals. The noncancer risk is 1.1E-01 (Table 10-21). If this value were added to the total noncancer hazard index already determined for the Resident-A child in the trial burn results (Table 10-13), resultant risk would only increase incrementally, and would still be below the hazard index benchmark of 1E+00.

In addition to the risk estimates based on predicted emission rates (Table 10-21), indirect or limited data are available on the potential noncancer risks for some of the chemicals, as discussed below.

Chlorophenylmethyl Sulfur Compounds and Organo-Phosphonates

Several of the chemicals not measured during the trial burn are by-products of the pesticide manufacturing process at the RMA and are believed to be present in the Basin F liquid. In particular, the following compounds are of special concern:

Chlorophenylmethyl sulfide (CPMS)
Chlorophenylmethyl sulfoxide (CPMSO)
Chlorophenylmethyl sulfone ($CPMSO_2$)
Diisopropylmethyl phosphonate (DIMP)
Dimethylmethyl phosphonate (DMMP)

Chromatograms from the semivolatile sampling train of the three samples of stack gas were reviewed to determine if any of these chemicals could be identified. Relative retention times were obtained from archived calibration of the specific compounds, and these were used to establish appropriate search windows. None of the chemicals were detectable in any of the samples of stack gas. Based on an estimated detection limit of 10 ug, and assuming a collection efficency of 10% (this is believed to be a conservative assumption), the maximum potential noncancer risk from exposure to each of the four chemicals of concern was calculated, as summarized in Table 10-22. As shown, all of the hazard index (HI) values are approximately five or more orders of magnitude less than the level of concern (HI > 1E+00). These results strongly support the conclusion that release of these compounds is not of concern at the SQI.

Silicon (Silica)

As discussed in Section 5, efforts were made to measure silica release during the trial burn, but contamination during sampling and/or laboratory analysis prevented use of the data. However, the maximum upper-bound noncancer risk from silica can be estimated by assuming that all of the particulate matter emitted from the SQI is in the form of silica (this is considered to be very unlikely). The results are shown in Table 10-23. Using the inhalation RfD value available in 1991, the highest possible HQ value would be 1.1E+00, and using the current inhalation RfD value for silica, the highest HQ value would be 5.6E-03. These findings support the conclusion that emission of silica is not likely to be of significant health concern at the SQI.

Sulfuric Acid Mist

Although sulfuric acid mist was not measured directly during the trial burn, two methods are available to estimate the maximum noncancer risk which this chemical might contribute. First, based on experience at other incinerators, the typical ratio of sulfuric acid to SO_2 is 0.10 or less. Based on the average release rate of SO_2 measured during the trial burn (0.55

g/sec), the expected release rate of sulfuric acid would be 0.055 g/sec or less. This is below the emission rate predicted in 1991 (0.37 g/sec), and would correspond to a maximum inhalation hazard index (that for the Resident A child) of 1.2E-02. Second, the absolute upper bound on risk can be estimated from measurements made of total sulfate release. Even if all sulfate released were in the form of sulfuric acid (this is not considered to be likely), the maximum hazard quotient would be 4.0E-01. These data strongly support the conclusion that release of sulfuric acid mist is not of concern at the SQI.

Ammonia

Ammonia release was not measured during the trial burn, but measurements were collected for this chemical during an earlier test (Shakedown Run Number 4, a three-day test burn of Basin F liquid very similar to the trial burn). In this test, the calculated hazard index for ammonia for the Resident A child was 5.6E-03 (WESTON 1993b). These data support the view that ammonia release is not of concern at the SQI.

10.4 RISK ASSOCIATED WITH EXPOSURE TO LEAD

Currently, there is not an EPA reference dose or slope factor available for lead. In the absence of these health criteria, the air concentrations of lead which were predicted for each of the scenarios were compared to the health risk based National Ambient Air Quality Standard (NAAQS) for lead as shown in Table 10-22. The results indicate that the predicted air concentrations of lead for each scenario are approximately 5 to 6 orders of magnitude lower than the NAAQS.

In addition, the increment in lead soil concentrations that were predicted for each of the scenarios were compared to an EPA recommended soil cleanup level for total lead of 500 to 1,000 mg/kg (EPA, 1989b). EPA adopted this level based on the recommendation made by the Centers for Disease Control (CDC) in a 1985 statement which is as follows: ". . . lead in soil and dust appears to be responsible for blood levels in children increasing above

background levels when the concentration in the soil or dust exceeds 500 to 1,000 ppm" (EPA, 1989b). The lower end of this range (500 ppm or 5.0E+02 mg/kg) was compared to predicted soil concentrations for the four scenarios at RMA in Table 10-18. The results indicate that the maximum predicted increment for soil lead for each scenario is approximately 8 orders of magnitude below the recommended soil cleanup level.

10.5 SUMMARY OF RESULTS

10.5.1 Cancer Risk

Figure 10-1 illustrates the estimated degree of cancer risk due to chemicals detected during the trial burn. The highest total lifetime cancer risk predicted for the reasonable maximum exposed individual at operating emissions conditions was the Farmer (3.1E-08). Even this low level of risk is questionable due to the blank contamination associated with BEHP, which was the primary contributor to risk. Even when the theoretical maximum risks which might be contributed by chemicals not detected or not measured are added, carcinogenic risks are still well below the benchmark level of concern (1E-06).

10.5.2 Noncancer Risk

Figure 10-2 illustrates the hazard indices for the adult, child and infant for the four scenarios. The highest noncancer risk calculated was associated with the Resident-A child (hazard index = 1.9E-02). This value is more than 50 times lower than the benchmark level of concern of 1E+00. Noncancer hazard indices would still be below this benchmark even if noncancer risks at the detection limit for chemicals not measured and/or not detected were added.

10.5.3 Lead Risks

Lead risk could not be quantified due to absence of EPA approved cancer and noncancer toxicity criteria. However, comparison of predicted ambient air concentrations and

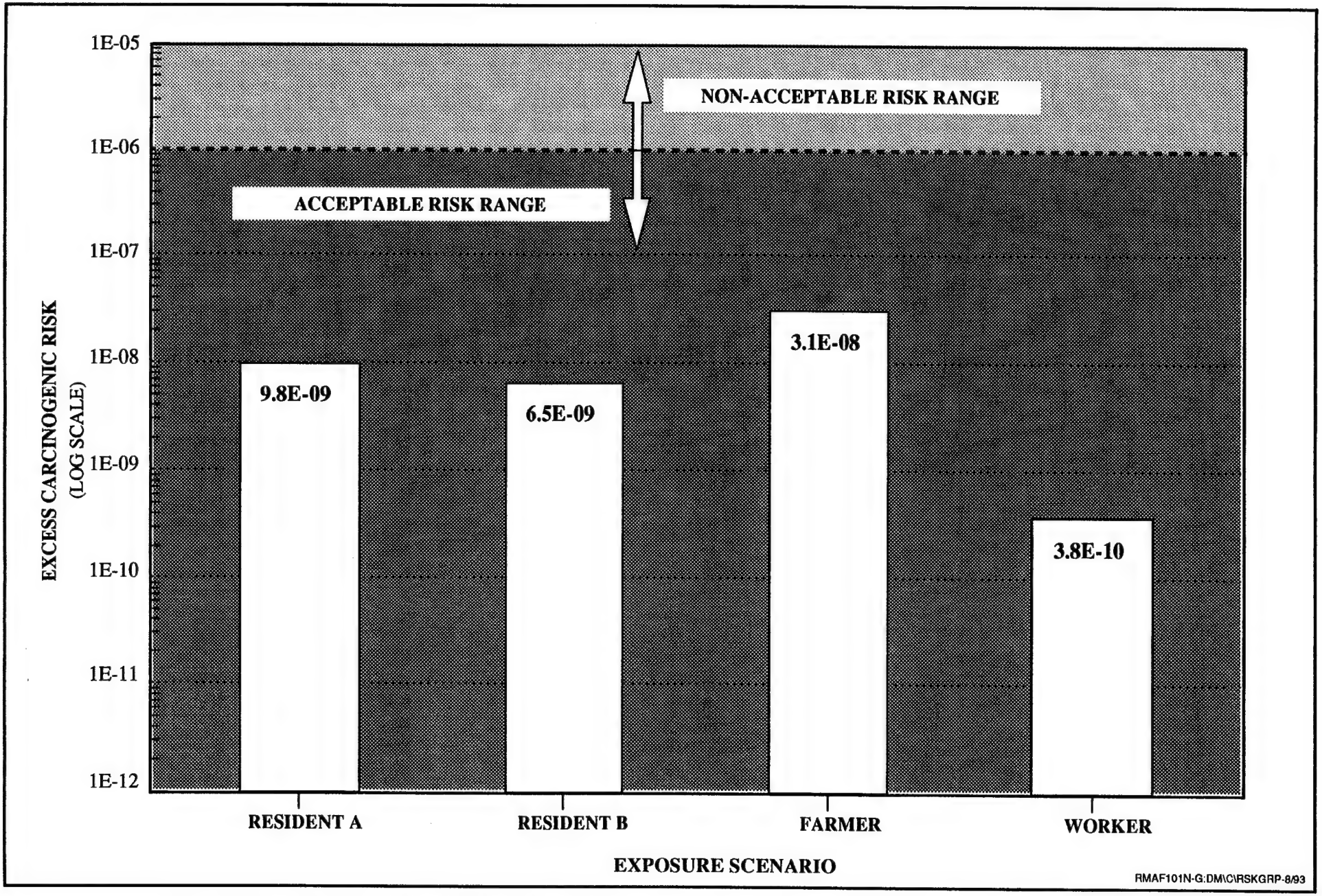

FIGURE 10-1 TOTAL LIFETIME CARCINOGENIC RISK FOR RESIDENT, FARMER AND ON-SITE WORKER EXPOSURE SCENARIOS (TRIAL BURN EMISSIONS RATES, FOR BASIN F LIQUID WASTE)

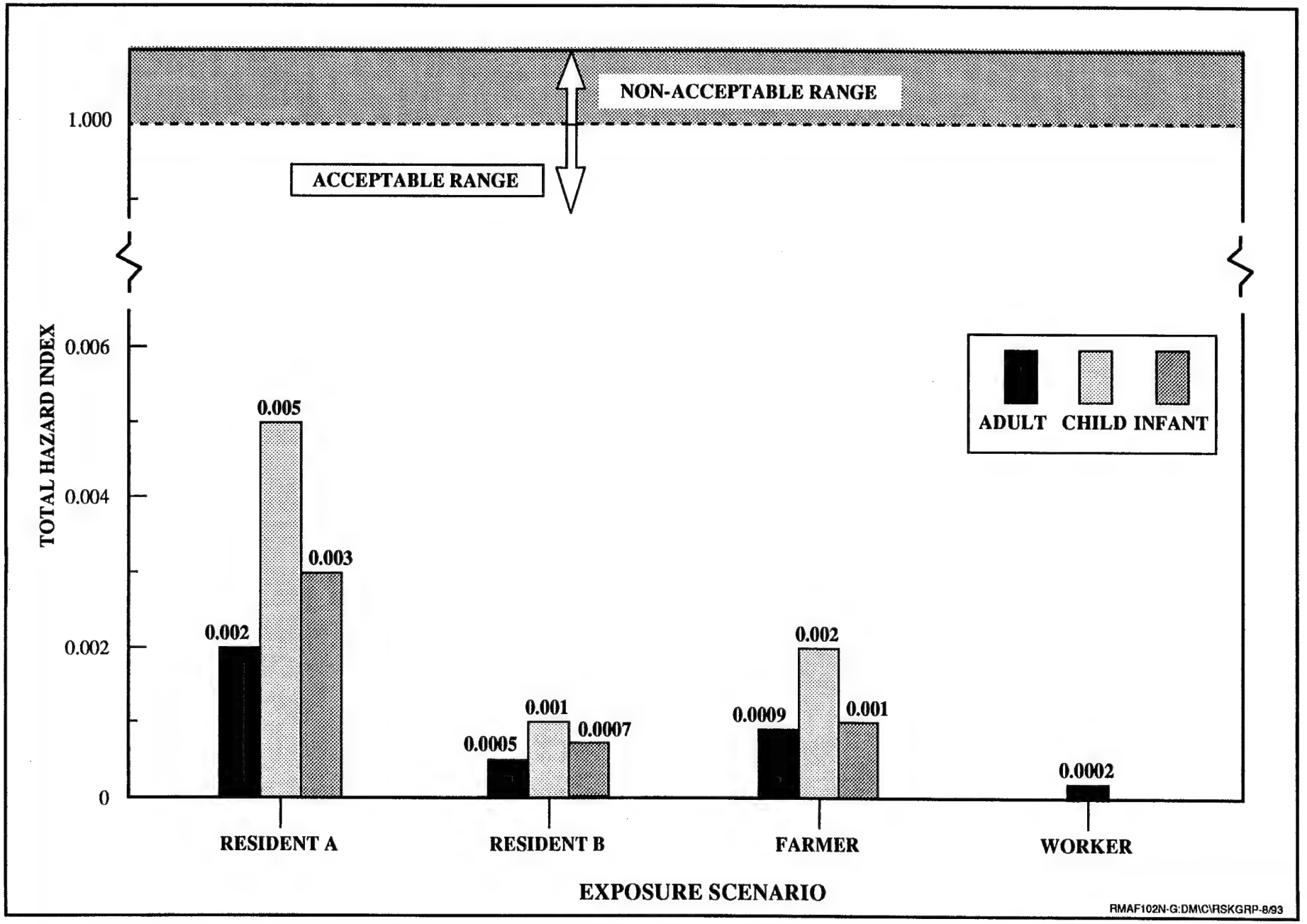

FIGURE 10-2 TOTAL HAZARD INDICES FOR RESIDENT, FARMER AND ON-SITE WORKER EXPOSURE SCENARIOS (TRIAL BURN EMISSIONS RATES FOR BASIN F LIQUID WASTE)

deposited soil levels with risk-based ARARs showed that these levels were five to six orders of magnitude lower than levels of concern.

10.5.4 General Conclusions

The results of this comprehensive multipathway human health risk assessment of the SQI during actual operation show that the facility does not pose unacceptable carcinogenic risk or noncarcinogenic health effects to sensitive populations, as defined by EPA guidance (EPA, 1989) and the *Final Decision Document* (Woodward-Clyde, 1990). In addition, the predicted air and soil levels are well below existing lead standards for air and soil (5 to 8 orders of magnitude) .

A discussion of the assumptions and uncertainties underlying these findings are presented in Section 11.

SECTION 10

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Table 10-1

Total Lifetime Resident-A Carcinogenic Risk Through the Inhalation, Ingestion, and Dermal Routes of Exposure

	Exposure Routes								
Pollutant	Inhalation	Mother's Milk Ingestion	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total
ORGANICS									
Benzene	1.92E-12	8.81E-16	NA	NA	NA	NA	NA	NA	1.93E-12
Bis(2-ethylhexyl)phthalate	1.46E-12	3.41E-13	3.08E-09	1.38E-11	1.30E-12	2.60E-14	9.92E-16	1.85E-14	3.10E-09
Bromodichloromethane	1.43E-11	1.31E-13	NA	NA	NA	NA	NA	NA	1.44E-11
Carbon Tetrachloride	7.86E-12	7.20E-14	NA	NA	NA	NA	NA	NA	7.93E-12
Chloroform	8.50E-11	5.86E-14	NA	NA	NA	NA	NA	NA	8.50E-11
Dibromochloromethane	3.59E-12	4.76E-14	4.07E-12	2.26E-16	7.26E-17	6.39E-14	9.76E-15	4.56E-14	7.83E-12
Dioxins/Furans (EPA TEFs)	2.49E-12	2.66E-11	9.71E-14	1.49E-14	1.02E-14	5.89E-14	9.98E-14	4.20E-14	2.94E-11
Heptachlor epoxide	1.35E-11	6.58E-12	7.52E-11	2.58E-14	6.52E-15	2.41E-13	1.22E-12	1.72E-13	9.70E-11
Methyl Chloride	4.75E-12	8.98E-14	NA	NA	NA	NA	NA	NA	4.84E-12
Methylene Chloride	1.65E-12	8.09E-15	NA	NA	NA	NA	NA	NA	1.66E-12
Styrene	1.13E-12	1.56E-13	NA	NA	NA	NA	NA	NA	1.29E-12
INORGANICS									
Arsenic	5.96E-09	NE	1.17E-11	9.26E-12	1.00E-13	1.24E-11	1.61E-12	8.82E-12	6.00E-09
Cadmium	1.24E-10	NA	NA	NA	NA	NA	NA	NA	1.24E-10
Chromium VI	3.42E-10	NA	NA	NA	NA	NA	NA	NA	3.42E-10
Nickel	3.17E-12	NA	NA	NA	NA	NA	NA	NA	3.17E-12
Total	6.56E-09	3.40E-11	3.18E-09	2.31E-11	1.42E-12	1.28E-11	2.94E-12	9.10E-12	9.82E-09

NA = Not applicable.
NE = Not evaluated.

Table 10-2

Total Lifetime Resident-B Carcinogenic Risk Through the Inhalation, Ingestion, and Dermal Routes of Exposure

	Exposure Routes								
Pollutant	Inhalation	Mother's Milk Ingestion	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total
ORGANICS									
Benzene	3.82E-13	1.75E-16	NA	NA	NA	NA	NA	NA	3.82E-13
Bis(2-ethylhexyl)phthalate	2.90E-13	5.26E-13	5.01E-09	1.38E-11	1.30E-12	4.22E-14	9.92E-16	3.01E-14	5.03E-09
Bromodichloromethane	2.83E-12	2.59E-14	NA	NA	NA	NA	NA	NA	2.86E-12
Carbon Tetrachloride	1.56E-12	1.43E-14	NA	NA	NA	NA	NA	NA	1.57E-12
Chloroform	1.68E-11	1.16E-14	NA	NA	NA	NA	NA	NA	1.69E-11
Dibromochloromethane	7.12E-13	1.31E-14	6.53E-12	2.26E-16	7.26E-17	1.04E-13	9.76E-15	7.41E-14	7.45E-12
Dioxins/Furans (EPA TEFs)	4.94E-13	5.44E-12	8.62E-14	1.49E-14	1.02E-14	9.56E-14	9.98E-14	6.82E-14	6.30E-12
Heptachlor epoxide	2.68E-12	3.41E-12	1.22E-10	2.58E-14	6.52E-15	3.91E-13	1.22E-12	2.79E-13	1.30E-10
Methyl Chloride	9.43E-13	1.78E-14	NA	NA	NA	NA	NA	NA	9.61E-13
Methylene Chloride	3.27E-13	1.60E-15	NA	NA	NA	NA	NA	NA	3.28E-13
Styrene	2.25E-13	3.09E-14	NA	NA	NA	NA	NA	NA	2.56E-13
INORGANICS									
Arsenic	1.18E-09	NE	3.90E-12	9.26E-12	1.00E-13	2.01E-11	1.61E-12	1.43E-11	1.23E-09
Cadmium	2.45E-11	NA	NA	NA	NA	NA	NA	NA	2.45E-11
Chromium VI	6.79E-11	NA	NA	NA	NA	NA	NA	NA	6.79E-11
Nickel	6.28E-13	NA	NA	NA	NA	NA	NA	NA	6.28E-13
Total	1.30E-09	9.48E-12	5.14E-09	2.31E-11	1.42E-12	2.07E-11	2.94E-12	1.48E-11	6.52E-09

NA = Not applicable.
NE = Not evaluated.

Table 10-3

Total Lifetime Farmer Carcinogenic Risk Through the Inhalation, Ingestion, and Dermal Routes of Exposure

	Exposure Routes								
Pollutant	Inhalation	Mother's Milk Ingestion	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total
ORGANICS									
Benzene	6.69E-13	3.06E-16	NA	NA	NA	NA	NA	NA	6.69E-13
Bis(2-ethylhexyl)phthalate	5.08E-13	3.30E-12	2.71E-08	2.76E-10	2.60E-11	2.52E-14	9.92E-16	6.05E-14	2.74E-08
Bromodichloromethane	4.96E-12	4.54E-14	NA	NA	NA	NA	NA	NA	5.00E-12
Carbon Tetrachloride	2.73E-12	2.50E-14	NA	NA	NA	NA	NA	NA	2.76E-12
Chloroform	2.95E-11	2.04E-14	NA	NA	NA	NA	NA	NA	2.96E-11
Dibromochloromethane	1.25E-12	3.29E-14	2.73E-11	4.52E-15	1.45E-15	6.21E-14	9.76E-15	1.49E-13	2.89E-11
Dioxins/Furans (EPA TEFs)	8.66E-13	1.19E-11	4.04E-13	2.98E-13	2.03E-13	5.71E-14	9.98E-14	1.37E-13	1.40E-11
Heptachlor epoxide	4.71E-12	1.42E-11	6.59E-10	5.16E-13	1.30E-13	2.34E-13	1.22E-12	5.60E-13	6.81E-10
Methyl Chloride	1.65E-12	3.12E-14	NA	NA	NA	NA	NA	NA	1.68E-12
Methylene Chloride	5.73E-13	2.81E-15	NA	NA	NA	NA	NA	NA	5.76E-13
Styrene	3.94E-13	5.42E-14	NA	NA	NA	NA	NA	NA	4.49E-13
INORGANICS									
Arsenic	2.07E-09	NE	8.91E-12	1.85E-10	2.00E-12	1.20E-11	1.61E-12	2.88E-11	2.31E-09
Cadmium	4.30E-11	NA	NA	NA	NA	NA	NA	NA	4.30E-11
Chromium VI	1.19E-10	NA	NA	NA	NA	NA	NA	NA	1.19E-10
Nickel	1.10E-12	NA	NA	NA	NA	NA	NA	NA	1.10E-12
Total	2.28E-09	2.96E-11	2.78E-08	4.62E-10	2.83E-11	1.24E-11	2.94E-12	2.97E-11	3.07E-08

NA = Not applicable.
NE = Not evaluated.

Table 10-4

Total Lifetime Worker Carcinogenic Risk Through the Inhalation, Ingestion, and Dermal Routes of Exposure

Pollutant	Exposure Routes			
	Inhalation	Soil/Dust Ingestion	Dermal Absorption	Total
ORGANICS				
Benzene	1.06E-13	NA	NA	1.06E-13
Bis(2-ethylhexyl)phthalate	8.01E-14	6.36E-15	2.64E-14	1.13E-13
Bromodichloromethane	7.83E-13	NA	NA	7.83E-13
Carbon Tetrachloride	4.31E-13	NA	NA	4.31E-13
Chloroform	4.66E-12	NA	NA	4.66E-12
Dibromochloromethane	1.97E-13	1.56E-14	6.50E-14	2.78E-13
Dioxins/Furans (EPA TEFs)	1.37E-13	1.44E-14	5.99E-14	2.11E-13
Heptachlor epoxide	7.43E-13	5.89E-14	2.45E-13	1.05E-12
Methyl Chloride	2.61E-13	NA	NA	2.61E-13
Methylene Chloride	9.04E-14	NA	NA	9.04E-14
Styrene	6.22E-14	NA	NA	6.22E-14
INORGANICS				
Arsenic	3.27E-10	3.02E-12	1.26E-11	3.42E-10
Cadmium	6.79E-12	NA	NA	6.79E-12
Chromium VI	1.88E-11	NA	NA	1.88E-11
Nickel	1.74E-13	NA	NA	1.74E-13
Total	3.60E-10	3.12E-12	1.30E-11	3.76E-10

NA = Not applicable.

Table 10-5

Distribution of Carcinogenic Risk by Pathway, as a Percent of Total Risk, for all Scenarios (Trial Burn Emissions Rates)

Route of Exposure	Resident-A	Resident-B	Farmer	Worker
Adult				
Inhalation	**NA**	**NA**	**NA**	**95.7**
Ingestion	**29.2**	**71.1**	**78.8**	**0.8**
Vegetable	28.9	70.6	77.7	NA
Milk	0.2	0.2	1.0	NA
Beef	0.01	0.02	0.08	NA
Soil/Dust	0.08	0.19	0.02	0.8
Fish	0.03	0.04	<0.01	NA
Dermal	**0.06**	**0.14**	**0.9**	**3.4**
Child				
Inhalation	**40.4**	**12.07**	**4.5**	**NA**
Ingestion	**3.5**	**8.5**	**13.6**	**NA**
Vegetables	3.4	8.3	13.0	NA
Milk	0.07	0.11	0.5	NA
Beef	<0.01	<0.01	0.02	NA
Soil/Dust	0.05	0.13	0.02	NA
Fish	<0.01	<0.01	<0.01	NA
Dermal	**0.04**	**0.09**	**0.01**	**NA**
Infant				
Inhalation	**26.4**	**7.9**	**2.9**	**NA**
Breast Milk	**0.35**	**0.15**	**0.1**	**NA**
TOTAL RISK	**9.8E-09**	**6.5E-09**	**3.1E-08**	**3.8E-10**

NA = Not applicable

Table 10-6

Inhalation[a] Carcinogenic Risk For Adult Resident, Farmer, and Worker Under Operating Conditions of the SQI

Exposure Scenario	Inhalation Carcinogenic Risk Based On Trial Burn Emissions
Adult Resident-A	3.5E-09
Adult Resident-B	7.0E-10
Adult Farmer	1.2E-09
Worker[b]	6.4E-10

[a] Exposure duration is adjusted for 2 years at average daily exposures.
[b] This is the inhalation risk that was determined under the "Worker" exposure scenario, and is shown for comparison to the off-site (resident) adults.

TABLE 10–7

CANCER RISKS OF CHEMICALS THAT WERE PREDICTED
BUT NOT DETECTED WHEN MEASURED
(TOTAL LIFETIME RESIDENT–A CANCER RISK)

CHEMICAL	TRIAL BURN SAMPLE DETECTION LIMIT (UG/CM)	CANCER RISK TO RESIDENT–A AT DETECTION LIMIT
i–BERYLLIUM	1.00E+00	5.57E–10
p–ALDRIN	1.30E–01	6.35E–09
p–DIELDRIN	1.30E–01	3.67E–08
p–P,P,–DDT	1.30E–01	1.04E–11
p–P,P–DDE	1.30E–01	6.54E–12
p–PARATHION	3.00E–01	NE
p–VAPONA	3.30E+00	2.76E–10
sv–BENZO[A]PYRENE	1.67E+01	2.01E–08
sv–CARBAZOLE	1.67E+01	7.12E–11
sv–CHRYSENE	1.67E+01	2.48E–08
sv–DIBENZO[A,H]ANTHRACENE	1.67E+01	6.12E–08
sv–HEXACHLOROBENZENE	1.67E+01	5.27E–09
sv–QUINOLINE	1.67E+01	9.95E–08
v–1,1–DICHLOROETHENE	3.00E+00	2.33E–10
v–1,2–DICHLOROPROPANE	3.00E+00	1.33E–11
v–1,4–DICHLOROBENZENE	3.00E+00	2.94E–13
v–TETRACHLOROETHENE	3.00E+00	7.08E–13
v–TRICHLROETHENE	3.00E+00	2.15E–12
v–VINYL CHLORIDE	3.00E+00	6.03E–11
	TOTAL RISK	2.55E–07

i = inorganic
v = volatile
sv = semivolatile
p = pesticide
g/sec = grams per second
ug/m3 = micrograms per cubic meter
NE = Not evaluated because toxicity criteria not available.

Table 10-8

Cancer Risk[a] of Predicted Chemicals Which Were Not Sampled During the Trial Burn

Chemical	Cancer Risk[a]
Acrylonitrile	1.60E-14

[a] Risk value was obtained from Tables 10-1 for Resident A in Final Draft Human Health Risk Assessment (WESTON, 1991).

Table 10-9

Adult Hazard Index for the Inhalation, Ingestion, and Dermal Routes of Exposure for the Resident-A Scenario

	Exposure Routes							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total (Hazard Index)
ORGANICS								
Benzene	3.81E-08	NA	NA	NA	NA	NA	NA	3.81E-08
Benzoic Acid	1.29E-09	7.98E-11	2.61E-15	9.36E-16	7.96E-13	1.04E-13	5.86E-13	1.37E-09
Bis(2-ethylhexyl)phthalate	3.83E-07	1.09E-05	1.29E-06	1.45E-07	6.04E-11	3.29E-12	4.44E-11	1.28E-05
Bromodichloromethane	2.16E-07	NA	NA	NA	NA	NA	NA	2.16E-07
Butylbenzylphthalate	6.87E-09	1.32E-07	1.46E-11	1.79E-12	4.24E-12	1.38E-12	3.12E-12	1.39E-07
Carbon Tetrachloride	3.59E-08	NA	NA	NA	NA	NA	NA	3.59E-08
Chlorobenzene	2.21E-07	NA	NA	NA	NA	NA	NA	2.21E-07
Chloroform	3.93E-07	NA	NA	NA	NA	NA	NA	3.93E-07
Dibromochloromethane	4.01E-08	3.41E-09	1.25E-13	4.26E-14	2.48E-11	5.40E-12	1.82E-11	4.35E-08
Di-n-butylphthalate	2.94E-08	9.46E-10	3.98E-11	5.00E-12	1.82E-11	NA	1.34E-11	3.04E-08
Diethylphthalate	5.09E-07	2.35E-10	1.40E-14	4.55E-15	2.01E-12	NA	1.48E-12	5.10E-07
Dimethylphthalate	1.93E-07	1.19E-11	2.96E-16	1.01E-16	6.08E-14	NA	4.48E-14	1.93E-07
Dioxins/Furans (EPA TEFs)	4.13E-07	1.13E-08	1.36E-09	5.62E-10	2.55E-10	6.19E-10	1.88E-10	4.27E-07
Heptachlor epoxide	2.14E-06	6.87E-07	1.86E-09	2.41E-10	1.32E-09	9.57E-09	9.75E-10	2.85E-06
Methyl Chloride	1.35E-07	NA	NA	NA	NA	NA	NA	1.35E-07
Methylene Chloride	2.57E-09	NA	NA	NA	NA	NA	NA	2.57E-09
Styrene	4.90E-08	NA	NA	NA	NA	NA	NA	4.90E-08
Toluene	4.58E-09	NA	NA	NA	NA	NA	NA	4.58E-09
Xylene	1.26E-08	NA	NA	NA	NA	NA	NA	1.26E-08
INORGANICS								
Aluminum	1.84E-05	NA	NA	NA	NA	NE	NA	1.84E-05
Antimony	4.05E-06	1.40E-07	2.17E-10	9.18E-11	3.19E-09	NA	2.35E-09	4.20E-06
Arsenic	3.65E-05	1.99E-07	2.13E-08	2.62E-10	4.60E-09	8.57E-10	3.38E-09	3.67E-05
Barium	1.48E-04	NA	NA	NA	NA	NA	NA	1.48E-04
Boron	1.68E-05	NA	NA	NA	NA	NE	NA	1.68E-05
Cadmium	7.45E-06	1.07E-08	2.21E-10	6.15E-12	2.35E-10	NA	1.73E-10	7.46E-06
Calcium	2.54E-04	NA	NA	NA	NA	NE	NA	2.54E-04
Chromium III	1.40E-06	NA	NA	NA	NA	NA	NA	1.40E-06

Table 10-9
(Continued)

	Exposure Routes							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total (Hazard Index)
Chromium VI	3.07E-06	NA	NA	NA	NA	NA	NA	3.07E-06
Copper	7.65E-05	5.92E-07	1.81E-08	7.24E-09	1.24E-08	7.43E-09	9.15E-09	7.72E-05
Iron	1.66E-05	NA	NA	NA	NA	NA	NA	1.66E-05
Manganese	1.12E-05	NA	NA	NA	NA	NA	NA	1.12E-05
Mercury	3.10E-04	2.61E-06	2.22E-08	8.18E-07	5.47E-08	NA	4.03E-08	3.14E-04
Molybdenum	1.46E-06	NA	NA	NA	NA	NE	NA	1.46E-06
Nickel	2.91E-05	NA	NA	NA	NA	NA	NA	2.91E-05
Silver	7.24E-05	NA	NA	NA	NA	NA	NA	7.24E-05
Tin	2.45E-06	NA	NA	NA	NA	NE	NA	2.45E-06
Titanium	1.22E-06	NA	NA	NA	NA	NE	NA	1.22E-06
Vanadium	7.28E-05	NA	NA	NA	NA	1.62E-12	NA	7.28E-05
Zinc	2.34E-05	NA	NA	NA	NA	1.73E-10	NA	2.34E-05
CRITERIA POLLUTANTS/ ACID GASES								
Hydrogen Chloride	5.11E-04	NA	NA	NA	NA	NA	NA	5.11E-04
Particulate Matter	5.94E-04	NA	NA	NA	NA	NA	NA	5.94E-04
Carbon Monoxide	5.41E-04	NA	NA	NA	NA	NA	NA	5.41E-04
Hydrogen Fluoride	4.16E-05	NA	NA	NA	NA	NA	NA	4.16E-05
Nitric Acid	2.08E-05	NA	NA	NA	NA	NA	NA	2.08E-05
Nitrogen Oxide	3.26E-03	NA	NA	NA	NA	NA	NA	3.26E-03
Sulfur Dioxide	2.41E-03	NA	NA	NA	NA	NA	NA	2.41E-03
Total (Hazard Index)	8.49E-03	1.53E-05	1.35E-06	9.71E-07	7.69E-08	1.87E-08	5.66E-08	8.51E-03

Table 10-10

Adult Hazard Index for the Inhalation, Ingestion, and Dermal Routes of Exposure for the Resident-B Scenario

	Exposure Routes							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total (Hazard Index)
ORGANICS								
Benzene	7.56E-09	NA	NA	NA	NA	NA	NA	7.56E-09
Benzoic Acid	2.56E-10	7.98E-11	2.61E-15	9.36E-16	1.29E-12	1.04E-13	9.51E-13	3.38E-10
Bis(2-ethylhexyl)phthalate	7.60E-08	1.78E-05	1.29E-06	1.45E-07	9.81E-11	3.29E-12	7.22E-11	1.93E-05
Bromodichloromethane	4.28E-08	NA	NA	NA	NA	NA	NA	4.28E-08
Butylbenzylphthalate	1.36E-09	2.14E-07	1.46E-11	1.79E-12	6.89E-12	1.38E-12	5.07E-12	2.16E-07
Carbon Tetrachloride	7.11E-09	NA	NA	NA	NA	NA	NA	7.11E-09
Chlorobenzene	4.37E-08	NA	NA	NA	NA	NA	NA	4.37E-08
Chloroform	7.80E-08	NA	NA	NA	NA	NA	NA	7.80E-08
Dibromochloromethane	7.94E-09	4.00E-09	1.25E-13	4.26E-14	4.02E-11	5.40E-12	2.96E-11	1.20E-08
Di-n-butylphthalate	5.83E-09	4.03E-10	3.98E-11	5.00E-12	2.95E-11	NA	2.17E-11	6.33E-09
Diethylphthalate	1.01E-07	2.57E-10	1.40E-14	4.55E-15	3.26E-12	NA	2.40E-12	1.01E-07
Dimethylphthalate	3.83E-08	1.56E-11	2.96E-16	1.01E-16	9.88E-14	NA	7.27E-14	3.83E-08
Dioxins/Furans (EPA TEFs)	8.19E-08	2.42E-09	1.36E-09	5.62E-10	4.15E-10	6.19E-10	3.05E-10	8.76E-08
Heptachlor epoxide	4.25E-07	1.03E-06	1.86E-09	2.41E-10	2.15E-09	9.57E-09	1.58E-09	1.47E-06
Methyl Chloride	2.67E-08	NA	NA	NA	NA	NA	NA	2.67E-08
Methylene Chloride	5.10E-10	NA	NA	NA	NA	NA	NA	5.10E-10
Styrene	9.71E-09	NA	NA	NA	NA	NA	NA	9.71E-09
Toluene	9.09E-10	NA	NA	NA	NA	NA	NA	9.09E-10
Xylene	2.51E-09	NA	NA	NA	NA	NA	NA	2.51E-09
INORGANICS								
Aluminum	3.65E-06	NA	NA	NA	NA	NE	NA	3.65E-06
Antimony	8.03E-07	2.80E-08	2.17E-10	9.18E-11	5.18E-09	NA	3.81E-09	8.41E-07
Arsenic	7.23E-06	3.56E-08	2.13E-08	2.62E-10	7.47E-09	8.57E-10	5.49E-09	7.30E-06
Barium	2.94E-05	NA	NA	NA	NA	NA	NA	2.94E-05
Boron	3.34E-06	NA	NA	NA	NA	NE	NA	3.34E-06
Cadmium	1.48E-06	2.70E-09	2.21E-10	6.15E-12	3.81E-10	NA	2.81E-10	1.48E-06
Calcium	5.04E-05	NA	NA	NA	NA	NE	NA	5.04E-05
Chromium III	2.77E-07	NA	NA	NA	NA	NA	NA	2.77E-07
Chromium VI	6.08E-07	NA	NA	NA	NA	NA	NA	6.08E-07
Copper	1.52E-05	1.84E-07	1.81E-08	7.24E-09	2.02E-08	7.43E-09	1.49E-08	1.54E-05

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Table 10-10
(Continued)

	Exposure Routes							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total (Hazard Index)
Iron	3.29E-06	NA	NA	NA	NA	NA	NA	3.29E-06
Manganese	2.22E-06	NA	NA	NA	NA	NA	NA	2.22E-06
Mercury	6.15E-05	8.18E-07	2.22E-08	8.18E-07	8.89E-08	NA	6.54E-08	6.33E-05
Molybdenum	2.89E-07	NA	NA	NA	NA	NE	NA	2.89E-07
Nickel	5.77E-06	NA	NA	NA	NA	NA	NA	5.77E-06
Silver	1.43E-05	NA	NA	NA	NA	NA	NA	1.43E-05
Tin	4.85E-07	NA	NA	NA	NA	NE	NA	4.85E-07
Titanium	2.41E-07	NA	NA	NA	NA	NE	NA	2.41E-07
Vanadium	1.44E-05	NA	NA	NA	NA	1.62E-12	NA	1.44E-05
Zinc	4.64E-06	NA	NA	NA	NA	1.73E-10	NA	4.64E-06
CRITERIA POLLUTANTS/ ACID GASES								
Hydrogen Chloride	1.01E-04	NA	NA	NA	NA	NA	NA	1.01E-04
Particulate Matter	1.18E-04	NA	NA	NA	NA	NA	NA	1.18E-04
Carbon Monoxide	1.07E-04	NA	NA	NA	NA	NA	NA	1.07E-04
Hydrogen Fluoride	8.25E-06	NA	NA	NA	NA	NA	NA	8.25E-06
Nitric Acid	4.13E-06	NA	NA	NA	NA	NA	NA	4.13E-06
Nitrogen Oxide	6.47E-04	NA	NA	NA	NA	NA	NA	6.47E-04
Sulfur Dioxide	4.78E-04	NA	NA	NA	NA	NA	NA	4.78E-04
Total (Hazard Index)	1.68E-03	2.01E-05	1.35E-06	9.71E-07	1.25E-07	1.87E-08	9.19E-08	1.70E-03

Table 10-11

Adult Hazard Index for the Inhalation, Ingestion, and Dermal Routes of Exposure for the Farmer Scenario

	Exposure Routes							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total (Hazard Index)
ORGANICS								
Benzene	1.33E-08	NA	NA	NA	NA	NA	NA	1.33E-08
Benzoic Acid	4.48E-10	1.74E-10	5.21E-14	1.87E-14	7.73E-13	1.04E-13	2.79E-12	6.26E-10
Bis(2-ethylhexyl)phthalate	1.33E-07	9.20E-05	2.58E-05	2.89E-06	5.86E-11	3.29E-12	2.11E-10	1.21E-04
Bromodichloromethane	7.49E-08	NA	NA	NA	NA	NA	NA	7.49E-08
Butylbenzylphthalate	2.39E-09	1.11E-06	2.92E-10	3.57E-11	4.12E-12	1.38E-12	1.49E-11	1.11E-06
Carbon Tetrachloride	1.25E-08	NA	NA	NA	NA	NA	NA	1.25E-08
Chlorobenzene	7.67E-08	NA	NA	NA	NA	NA	NA	7.67E-08
Chloroform	1.37E-07	NA	NA	NA	NA	NA	NA	1.37E-07
Dibromochloromethane	1.39E-08	1.60E-08	2.49E-12	8.52E-13	2.40E-11	5.40E-12	8.67E-11	3.01E-08
Di-n-butylphthalate	1.02E-08	1.76E-09	7.96E-10	1.00E-10	1.76E-11	NA	6.36E-11	1.30E-08
Diethylphthalate	1.77E-07	1.05E-09	2.79E-13	9.09E-14	1.95E-12	NA	7.02E-12	1.78E-07
Dimethylphthalate	6.71E-08	6.88E-11	5.91E-15	2.03E-15	5.91E-14	NA	2.13E-13	6.72E-08
Dioxins/Furans (EPA TEFs)	1.44E-07	8.26E-09	2.71E-08	1.12E-08	2.48E-10	6.19E-10	8.94E-10	1.92E-07
Heptachlor epoxide	7.45E-07	5.32E-06	3.72E-08	4.82E-09	1.29E-09	9.57E-09	4.64E-09	6.13E-06
Methyl Chloride	4.68E-08	NA	NA	NA	NA	NA	NA	4.68E-08
Methylene Chloride	8.95E-10	NA	NA	NA	NA	NA	NA	8.95E-10
Styrene	1.70E-08	NA	NA	NA	NA	NA	NA	1.70E-08
Toluene	1.59E-09	NA	NA	NA	NA	NA	NA	1.59E-09
Xylene	4.39E-09	NA	NA	NA	NA	NA	NA	4.39E-09
INORGANICS								
Aluminum	6.39E-06	NA	NA	NA	NA	NE	NA	6.39E-06
Antimony	1.41E-06	7.98E-08	4.35E-09	1.84E-09	3.10E-09	NA	1.12E-08	1.51E-06
Arsenic	1.27E-05	1.07E-07	4.26E-07	5.23E-09	4.46E-09	8.57E-10	1.61E-08	1.32E-05
Barium	5.16E-05	NA	NA	NA	NA	NA	NA	5.16E-05
Boron	5.85E-06	NA	NA	NA	NA	NE	NA	5.85E-06
Cadmium	2.59E-06	7.26E-09	4.41E-09	1.23E-10	2.28E-10	NA	8.22E-10	2.60E-06
Calcium	8.83E-05	NA	NA	NA	NA	NE	NA	8.83E-05

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Table 10-11
(Continued)

	Exposure Routes							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total (Hazard Index)
Chromium III	4.86E-07	NA	NA	NA	NA	NA	NA	4.86E-07
Chromium VI	1.07E-06	NA	NA	NA	NA	NA	NA	1.07E-06
Copper	2.66E-05	4.57E-07	3.62E-07	1.45E-07	1.21E-08	7.43E-09	4.36E-08	2.76E-05
Iron	5.78E-06	NA	NA	NA	NA	NA	NA	5.78E-06
Manganese	3.89E-06	NA	NA	NA	NA	NA	NA	3.89E-06
Mercury	1.08E-04	1.94E-06	4.44E-07	1.64E-05	5.31E-08	NA	1.92E-07	1.27E-04
Molybdenum	5.07E-07	NA	NA	NA	NA	NE	NA	5.07E-07
Nickel	1.01E-05	NA	NA	NA	NA	NA	NA	1.01E-05
Silver	2.52E-05	NA	NA	NA	NA	NA	NA	2.52E-05
Tin	8.51E-07	NA	NA	NA	NA	NE	NA	8.51E-07
Titanium	4.23E-07	NA	NA	NA	NA	NE	NA	4.23E-07
Vanadium	2.53E-05	NA	NA	NA	NA	1.62E-12	NA	2.53E-05
Zinc	8.13E-06	NA	NA	NA	NA	1.73E-10	NA	8.13E-06
CRITERIA POLLUTANTS/ ACID GASES								
Hydrogen Chloride	1.78E-04	NA	NA	NA	NA	NA	NA	1.78E-04
Particulate Matter	2.06E-04	NA	NA	NA	NA	NA	NA	2.06E-04
Carbon Monoxide	1.88E-04	NA	NA	NA	NA	NA	NA	1.88E-04
Hydrogen Fluoride	1.45E-05	NA	NA	NA	NA	NA	NA	1.45E-05
Nitric Acid	7.23E-06	NA	NA	NA	NA	NA	NA	7.23E-06
Nitrogen Oxide	1.13E-03	NA	NA	NA	NA	NA	NA	1.13E-03
Sulfur Dioxide	8.37E-04	NA	NA	NA	NA	NA	NA	8.37E-04
Total (Hazard Index)	2.96E-03	1.01E-04	2.71E-05	1.94E-05	7.46E-08	1.87E-08	2.69E-07	3.10E-03

Table 10-12

Adult Hazard Index for the Inhalation, Ingestion, and Dermal Routes of Exposure for the Worker Scenario

Pollutant	Exposure Routes: Inhalation	Soil/Dust Ingestion	Dermal Absorption	Total
ORGANICS				
Benzene	3.91E-09	NA	NA	3.91E-09
Benzoic Acid	1.32E-10	7.08E-13	2.95E-12	1.36E-10
Bis(2-ethylhexyl)phthalate	3.93E-08	5.37E-11	2.24E-10	3.96E-08
Bromodichloromethane	2.21E-08	NA	NA	2.21E-08
Butylbenzylphthalate	7.04E-10	3.78E-12	1.57E-11	7.23E-10
Carbon Tetrachloride	3.67E-09	NA	NA	3.67E-09
Chlorobenzene	2.26E-08	NA	NA	2.26E-08
Chloroform	4.03E-08	NA	NA	4.03E-08
Dibromochloromethane	4.10E-09	2.20E-11	9.16E-11	4.22E-09
Di-n-butylphthalate	3.01E-09	1.62E-11	6.72E-11	3.09E-09
Diethylphthalate	5.22E-08	1.78E-12	7.42E-12	5.22E-08
Dimethylphthalate	1.98E-08	5.41E-14	2.25E-13	1.98E-08
Dioxins/Furans (EPA TEFs)	4.23E-08	2.27E-10	9.45E-10	4.35E-08
Heptachlor epoxide	2.20E-07	1.18E-09	4.90E-09	2.26E-07
Methyl Chloride	1.38E-08	NA	NA	1.38E-08
Methylene Chloride	2.64E-10	NA	NA	2.64E-10
Styrene	5.02E-09	NA	NA	5.02E-09
Toluene	4.70E-10	NA	NA	4.70E-10
Xylene	1.29E-09	NA	NA	1.29E-09
INORGANICS				
Aluminum	1.88E-06	NA	NA	1.88E-06
Antimony	4.15E-07	2.84E-09	1.18E-08	4.30E-07
Arsenic	3.74E-06	4.09E-09	1.70E-08	3.76E-06
Barium	1.52E-05	NA	NA	1.52E-05
Boron	1.72E-06	NA	NA	1.72E-06
Cadmium	7.63E-07	2.09E-10	8.69E-10	7.65E-07
Calcium	2.60E-05	NA	NA	2.60E-05
Chromium III	1.43E-07	NA	NA	1.43E-07
Chromium VI	3.14E-07	NA	NA	3.14E-07
Copper	7.84E-06	1.11E-08	4.60E-08	7.90E-06
Iron	1.70E-06	NA	NA	1.70E-06
Manganese	1.15E-06	NA	NA	1.15E-06
Mercury	3.18E-05	4.87E-08	2.03E-07	3.20E-05
Molybdenum	1.49E-07	NA	NA	1.49E-07
Nickel	2.98E-06	NA	NA	2.98E-06
Silver	7.41E-06	NA	NA	7.41E-06
Tin	2.51E-07	NA	NA	2.51E-07
Titanium	1.25E-07	NA	NA	1.25E-07
Vanadium	7.45E-06	NA	NA	7.45E-06
Zinc	2.40E-06	NA	NA	2.40E-06
CRITERIA POLLUTANTS/ ACID GASES				
Hydrogen Chloride	5.24E-05	NA	NA	5.24E-05
Particulate Matter	6.08E-05	NA	NA	6.08E-05
Carbon Monoxide	5.54E-05	NA	NA	5.54E-05
Hydrogen Fluoride	4.26E-06	NA	NA	4.26E-06
Nitric Acid	2.13E-06	NA	NA	2.13E-06
Nitrogen Oxide	3.34E-04	NA	NA	3.34E-04
Sulfur Dioxide	2.47E-04	NA	NA	2.47E-04
Total (Hazard Index)	8.70E-04	6.84E-08	2.85E-07	8.71E-04

Table 10-13

Child Hazard Index for the Inhalation, Ingestion, and Dermal Routes of Exposure for the Resident-A Scenario

	Exposure Routes							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total (Hazard Index)
ORGANICS								
Benzene	8.61E-08	NA	NA	NA	NA	NA	NA	8.61E-08
Benzoic Acid	2.91E-09	1.52E-10	1.51E-14	2.33E-15	7.19E-12	2.36E-13	4.90E-12	3.07E-09
Bis(2-ethylhexyl)phthalate	8.66E-07	1.64E-05	7.45E-06	3.61E-07	5.46E-10	7.44E-12	3.72E-10	2.51E-05
Bromodichloromethane	4.87E-07	NA	NA	NA	NA	NA	NA	4.87E-07
Butylbenzylphthalate	1.55E-08	1.98E-07	8.42E-11	4.46E-12	3.83E-11	3.11E-12	2.61E-11	2.13E-07
Carbon Tetrachloride	8.10E-08	NA	NA	NA	NA	NA	NA	8.10E-08
Chlorobenzene	4.98E-07	NA	NA	NA	NA	NA	NA	4.98E-07
Chloroform	8.88E-07	NA	NA	NA	NA	NA	NA	8.88E-07
Dibromochloromethane	9.05E-08	5.88E-09	7.20E-13	1.06E-13	2.24E-10	1.22E-11	1.52E-10	9.67E-08
Di-n-butylphthalate	6.64E-08	1.70E-09	2.30E-10	1.25E-11	1.64E-10	NA	1.12E-10	6.86E-08
Diethylphthalate	1.15E-06	4.05E-10	8.07E-14	1.13E-14	1.81E-11	NA	1.23E-11	1.15E-06
Dimethylphthalate	4.36E-07	1.98E-11	1.71E-15	2.53E-16	5.50E-13	NA	3.74E-13	4.36E-07
Dioxins/Furans (EPA TEFs)	9.33E-07	2.09E-08	8.91E-09	1.52E-09	2.31E-09	1.40E-09	1.57E-09	9.70E-07
Heptachlor epoxide	4.84E-06	1.05E-06	1.07E-08	6.01E-10	1.20E-08	2.16E-08	8.15E-09	5.94E-06
Methyl Chloride	3.04E-07	NA	NA	NA	NA	NA	NA	3.04E-07
Methylene Chloride	5.81E-09	NA	NA	NA	NA	NA	NA	5.81E-09
Styrene	1.11E-07	NA	NA	NA	NA	NA	NA	1.11E-07
Toluene	1.04E-08	NA	NA	NA	NA	NA	NA	1.04E-08
Xylene	2.85E-08	NA	NA	NA	NA	NA	NA	2.85E-08
INORGANICS								
Aluminum	4.15E-05	NA	NA	NA	NA	NE	NA	4.15E-05
Antimony	9.15E-06	2.58E-07	1.25E-09	2.29E-10	2.88E-08	NA	1.96E-08	9.46E-06
Arsenic	8.24E-05	3.68E-07	1.23E-07	6.53E-10	4.15E-08	1.93E-09	2.83E-08	8.29E-05
Barium	3.35E-04	NA	NA	NA	NA	NA	NA	3.35E-04
Boron	3.80E-05	NA	NA	NA	NA	NE	NA	3.80E-05
Cadmium	1.68E-05	1.99E-08	1.27E-09	1.53E-11	2.12E-09	NA	1.44E-09	1.69E-05
Calcium	5.74E-04	NA	NA	NA	NA	NE	NA	5.74E-04
Chromium III	3.16E-06	NA	NA	NA	NA	NA	NA	3.16E-06

Table 10-13
(Continued)

	Exposure Routes							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total (Hazard Index)
Chromium VI	6.93E-06	NA	NA	NA	NA	NA	NA	6.93E-06
Copper	1.73E-04	1.10E-06	1.04E-07	1.80E-08	1.12E-07	1.68E-08	7.65E-08	1.74E-04
Iron	3.75E-05	NA	NA	NA	NA	NA	NA	3.75E-05
Manganese	2.53E-05	NA	NA	NA	NA	NA	NA	2.53E-05
Mercury	7.00E-04	4.77E-06	1.28E-07	2.04E-06	4.94E-07	NA	3.37E-07	7.08E-04
Molybdenum	3.29E-06	NA	NA	NA	NA	NE	NA	3.29E-06
Nickel	6.57E-05	NA	NA	NA	NA	NA	NA	6.57E-05
Silver	1.63E-04	NA	NA	NA	NA	NA	NA	1.63E-04
Tin	5.53E-06	NA	NA	NA	NA	NE	NA	5.53E-06
Titanium	2.75E-06	NA	NA	NA	NA	NE	NA	2.75E-06
Vanadium	1.64E-04	NA	NA	NA	NA	3.66E-12	NA	1.64E-04
Zinc	5.28E-05	NA	NA	NA	NA	3.90E-10	NA	5.28E-05
CRITERIA POLLUTANTS/ ACID GASES								
Hydrogen Chloride	1.15E-03	NA	NA	NA	NA	NA	NA	1.15E-03
Particulate Matter	1.34E-03	NA	NA	NA	NA	NA	NA	1.34E-03
Carbon Monoxide	1.22E-03	NA	NA	NA	NA	NA	NA	1.22E-03
Hydrogen Fluoride	9.40E-05	NA	NA	NA	NA	NA	NA	9.40E-05
Nitric Acid	4.70E-05	NA	NA	NA	NA	NA	NA	4.70E-05
Nitrogen Oxide	7.36E-03	NA	NA	NA	NA	NA	NA	7.36E-03
Sulfur Dioxide	5.44E-03	NA	NA	NA	NA	NA	NA	5.44E-03
Total (Hazard Index)	1.92E-02	2.42E-05	7.83E-06	2.42E-06	6.94E-07	4.21E-08	4.73E-07	1.92E-02

Table 10-14

Child Hazard Index for the Inhalation, Ingestion, and Dermal Routes of Exposure for the Resident-B Scenario

	Exposure Routes							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total (Hazard Index)
ORGANICS								
Benzene	1.71E-08	NA	NA	NA	NA	NA	NA	1.71E-08
Benzoic Acid	5.77E-10	1.55E-10	1.51E-14	2.33E-15	1.17E-11	2.36E-13	7.96E-12	7.51E-10
Bis(2-ethylhexyl)phthalate	1.72E-07	2.66E-05	7.45E-06	3.61E-07	8.86E-10	7.44E-12	6.04E-10	3.46E-05
Bromodichloromethane	9.65E-08	NA	NA	NA	NA	NA	NA	9.65E-08
Butylbenzylphthalate	3.08E-09	3.21E-07	8.42E-11	4.46E-12	6.23E-11	3.11E-12	4.24E-11	3.24E-07
Carbon Tetrachloride	1.61E-08	NA	NA	NA	NA	NA	NA	1.61E-08
Chlorobenzene	9.88E-08	NA	NA	NA	NA	NA	NA	9.88E-08
Chloroform	1.76E-07	NA	NA	NA	NA	NA	NA	1.76E-07
Dibromochloromethane	1.79E-08	6.68E-09	7.20E-13	1.06E-13	3.63E-10	1.22E-11	2.47E-10	2.52E-08
Di-n-butylphthalate	1.32E-08	6.56E-10	2.30E-10	1.25E-11	2.66E-10	NA	1.81E-10	1.45E-08
Diethylphthalate	2.28E-07	4.26E-10	8.07E-14	1.13E-14	2.94E-11	NA	2.00E-11	2.29E-07
Dimethylphthalate	8.65E-08	2.51E-11	1.71E-15	2.53E-16	8.93E-13	NA	6.08E-13	8.65E-08
Dioxins/Furans (EPA TEFs)	1.85E-07	4.34E-09	8.91E-09	1.52E-09	3.75E-09	1.40E-09	2.55E-09	2.07E-07
Heptachlor epoxide	9.60E-07	1.55E-06	1.07E-08	6.01E-10	1.94E-08	2.16E-08	1.32E-08	2.58E-06
Methyl Chloride	6.03E-08	NA	NA	NA	NA	NA	NA	6.03E-08
Methylene Chloride	1.15E-09	NA	NA	NA	NA	NA	NA	1.15E-09
Styrene	2.19E-08	NA	NA	NA	NA	NA	NA	2.19E-08
Toluene	2.05E-09	NA	NA	NA	NA	NA	NA	2.05E-09
Xylene	5.66E-09	NA	NA	NA	NA	NA	NA	5.66E-09
INORGANICS								
Aluminum	8.23E-06	NA	NA	NA	NA	NE	NA	8.23E-06
Antimony	1.81E-06	5.01E-08	1.25E-09	2.29E-10	4.68E-08	NA	3.19E-08	1.94E-06
Arsenic	1.63E-05	6.54E-08	1.23E-07	6.53E-10	6.75E-08	1.93E-09	4.59E-08	1.66E-05
Barium	6.65E-05	NA	NA	NA	NA	NA	NA	6.65E-05
Boron	7.54E-06	NA	NA	NA	NA	NE	NA	7.54E-06
Cadmium	3.34E-06	5.15E-09	1.27E-09	1.53E-11	3.45E-09	NA	2.35E-09	3.35E-06
Calcium	1.14E-04	NA	NA	NA	NA	NE	NA	1.14E-04
Chromium III	6.26E-07	NA	NA	NA	NA	NA	NA	6.26E-07

Table 10-14
(Continued)

	Exposure Routes							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total (Hazard Index)
Chromium VI	1.37E-06	NA	NA	NA	NA	NA	NA	1.37E-06
Copper	3.43E-05	3.43E-07	1.04E-07	1.80E-08	1.83E-07	1.68E-08	1.24E-07	3.51E-05
Iron	7.44E-06	NA	NA	NA	NA	NA	NA	7.44E-06
Manganese	5.01E-06	NA	NA	NA	NA	NA	NA	5.01E-06
Mercury	1.39E-04	1.40E-06	1.28E-07	2.04E-06	8.03E-07	NA	5.47E-07	1.44E-04
Molybdenum	6.53E-07	NA	NA	NA	NA	NE	NA	6.53E-07
Nickel	1.30E-05	NA	NA	NA	NA	NA	NA	1.30E-05
Silver	3.24E-05	NA	NA	NA	NA	NA	NA	3.24E-05
Tin	1.10E-06	NA	NA	NA	NA	NE	NA	1.10E-06
Titanium	5.45E-07	NA	NA	NA	NA	NE	NA	5.45E-07
Vanadium	3.26E-05	NA	NA	NA	NA	3.66E-12	NA	3.26E-05
Zinc	1.05E-05	NA	NA	NA	NA	3.90E-10	NA	1.05E-05
CRITERIA POLLUTANTS/ ACID GASES								
Hydrogen Chloride	2.29E-04	NA	NA	NA	NA	NA	NA	2.29E-04
Particulate Matter	2.66E-04	NA	NA	NA	NA	NA	NA	2.66E-04
Carbon Monoxide	2.42E-04	NA	NA	NA	NA	NA	NA	2.42E-04
Hydrogen Fluoride	1.86E-05	NA	NA	NA	NA	NA	NA	1.86E-05
Nitric Acid	9.32E-06	NA	NA	NA	NA	NA	NA	9.32E-06
Nitrogen Oxide	1.46E-03	NA	NA	NA	NA	NA	NA	1.46E-03
Sulfur Dioxide	1.08E-03	NA	NA	NA	NA	NA	NA	1.08E-03
Total (Hazard Index)	3.80E-03	3.04E-05	7.83E-06	2.42E-06	1.13E-06	4.21E-08	7.68E-07	3.85E-03

Table 10-15

Child Hazard Index for the Inhalation, Ingestion, and Dermal Routes of Exposure for the Farmer Scenario

	Exposure Routes							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total (Hazard Index)
ORGANICS								
Benzene	2.99E-08	NA	NA	NA	NA	NA	NA	2.99E-08
Benzoic Acid	1.01E-09	3.68E-10	3.01E-13	4.67E-14	6.98E-12	2.36E-13	4.76E-12	1.39E-09
Bis(2-ethylhexyl)phthalate	3.01E-07	1.98E-04	1.49E-04	7.21E-06	5.30E-10	7.44E-12	3.61E-10	3.54E-04
Bromodichloromethane	1.69E-07	NA	NA	NA	NA	NA	NA	1.69E-07
Butylbenzylphthalate	5.39E-09	2.38E-06	1.68E-09	8.91E-11	3.72E-11	3.11E-12	2.53E-11	2.39E-06
Carbon Tetrachloride	2.81E-08	NA	NA	NA	NA	NA	NA	2.81E-08
Chlorobenzene	1.73E-07	NA	NA	NA	NA	NA	NA	1.73E-07
Chloroform	3.09E-07	NA	NA	NA	NA	NA	NA	3.09E-07
Dibromochloromethane	3.14E-08	3.43E-08	1.44E-11	2.12E-12	2.17E-10	1.22E-11	1.48E-10	6.61E-08
Di-n-butylphthalate	2.31E-08	3.67E-09	4.60E-09	2.49E-10	1.59E-10	NA	1.08E-10	3.18E-08
Diethylphthalate	4.00E-07	2.25E-09	1.61E-12	2.27E-13	1.76E-11	NA	1.20E-11	4.02E-07
Dimethylphthalate	1.52E-07	1.47E-10	3.41E-14	5.06E-15	5.34E-13	NA	3.63E-13	1.52E-07
Dioxins/Furans (EPA TEFs)	3.24E-07	1.60E-08	1.78E-07	3.05E-08	2.24E-09	1.40E-09	1.52E-09	5.54E-07
Heptachlor epoxide	1.68E-06	1.14E-05	2.15E-07	1.20E-08	1.16E-08	2.16E-08	7.91E-09	1.34E-05
Methyl Chloride	1.06E-07	NA	NA	NA	NA	NA	NA	1.06E-07
Methylene Chloride	2.02E-09	NA	NA	NA	NA	NA	NA	2.02E-09
Styrene	3.84E-08	NA	NA	NA	NA	NA	NA	3.84E-08
Toluene	3.60E-09	NA	NA	NA	NA	NA	NA	3.60E-09
Xylene	9.92E-09	NA	NA	NA	NA	NA	NA	9.92E-09
INORGANICS								
Aluminum	1.44E-05	NA	NA	NA	NA	NE	NA	1.44E-05
Antimony	3.18E-06	1.47E-07	2.51E-08	4.58E-09	2.80E-08	NA	1.91E-08	3.40E-06
Arsenic	2.86E-05	1.99E-07	2.46E-06	1.31E-08	4.03E-08	1.93E-09	2.75E-08	3.14E-05
Barium	1.16E-04	NA	NA	NA	NA	NA	NA	1.16E-04
Boron	1.32E-05	NA	NA	NA	NA	NE	NA	1.32E-05
Cadmium	5.85E-06	1.40E-08	2.55E-08	3.07E-10	2.06E-09	NA	1.40E-09	5.89E-06
Calcium	1.99E-04	NA	NA	NA	NA	NE	NA	1.99E-04

Table 10-15
(Continued)

	Exposure Routes							
	Inhalation	Vegetable Ingestion	Milk Ingestion	Beef Ingestion	Soil/Dust Ingestion	Fish Ingestion	Dermal Absorption	Total (Hazard Index)
Chromium III	1.10E-06	NA	NA	NA	NA	NA	NA	1.10E-06
Chromium VI	2.41E-06	NA	NA	NA	NA	NA	NA	2.41E-06
Copper	6.01E-05	8.88E-07	2.09E-06	3.61E-07	1.09E-07	1.68E-08	7.43E-08	6.36E-05
Iron	1.30E-05	NA	NA	NA	NA	NA	NA	1.30E-05
Manganese	8.79E-06	NA	NA	NA	NA	NA	NA	8.79E-06
Mercury	2.43E-04	3.63E-06	2.56E-06	4.08E-05	4.80E-07	NA	3.27E-07	2.91E-04
Molybdenum	1.15E-06	NA	NA	NA	NA	NE	NA	1.15E-06
Nickel	2.28E-05	NA	NA	NA	NA	NA	NA	2.28E-05
Silver	5.68E-05	NA	NA	NA	NA	NA	NA	5.68E-05
Tin	1.92E-06	NA	NA	NA	NA	NE	NA	1.92E-06
Titanium	9.56E-07	NA	NA	NA	NA	NE	NA	9.56E-07
Vanadium	5.71E-05	NA	NA	NA	NA	3.66E-12	NA	5.71E-05
Zinc	1.84E-05	NA	NA	NA	NA	3.90E-10	NA	1.84E-05
CRITERIA POLLUTANTS/ ACID GASES								
Hydrogen Chloride	4.01E-04	NA	NA	NA	NA	NA	NA	4.01E-04
Particulate Matter	4.66E-04	NA	NA	NA	NA	NA	NA	4.66E-04
Carbon Monoxide	4.24E-04	NA	NA	NA	NA	NA	NA	4.24E-04
Hydrogen Fluoride	3.27E-05	NA	NA	NA	NA	NA	NA	3.27E-05
Nitric Acid	1.63E-05	NA	NA	NA	NA	NA	NA	1.63E-05
Nitrogen Oxide	2.56E-03	NA	NA	NA	NA	NA	NA	2.56E-03
Sulfur Dioxide	1.89E-03	NA	NA	NA	NA	NA	NA	1.89E-03
Total (Hazard Index)	6.66E-03	2.17E-04	1.57E-04	4.84E-05	6.74E-07	4.21E-08	4.59E-07	7.08E-03

Table 10-16

Infant Hazard Index for the Inhalation and Mother's Milk Ingestion Routes of Exposure for the Resident-A Scenario

Pollutant	Exposure Routes: Inhalation	Exposure Routes: Mother's Milk Ingestion	Total (Hazard Index)
ORGANICS			
Benzene	5.64E-08	2.13E-09	5.85E-08
Benzoic Acid	1.90E-09	1.87E-09	3.78E-09
Bis(2-ethylhexyl)phthalate	5.67E-07	8.53E-08	6.52E-07
Bromodichloromethane	3.19E-07	7.37E-09	3.26E-07
Butylbenzylphthalate	1.02E-08	1.90E-08	2.92E-08
Carbon Tetrachloride	5.30E-08	5.54E-08	1.08E-07
Chlorobenzene	3.26E-07	1.89E-09	3.28E-07
Chloroform	5.81E-07	6.72E-08	6.48E-07
Dibromochloromethane	5.92E-08	1.98E-09	6.12E-08
Di-n-butylphthalate	4.34E-08	4.16E-09	4.76E-08
Diethylphthalate	7.53E-07	4.77E-10	7.53E-07
Dimethylphthalate	2.85E-07	1.51E-11	2.85E-07
Dioxins/Furans (EPA TEFs)	6.11E-07	1.24E-05	1.30E-05
Heptachlor epoxide	3.17E-06	3.89E-06	7.06E-06
Methyl Chloride	1.99E-07	2.69E-08	2.26E-07
Methylene Chloride	3.80E-09	1.26E-09	5.06E-09
Styrene	7.24E-08	1.82E-09	7.42E-08
Toluene	6.77E-09	5.60E-11	6.83E-09
Xylene	1.87E-08	4.63E-13	1.87E-08
INORGANICS			
Aluminum	2.72E-05	NE	2.72E-05
Antimony	5.99E-06	NE	5.99E-06
Arsenic	5.39E-05	NE	5.39E-05
Barium	2.19E-04	NE	2.19E-04
Boron	2.49E-05	NE	2.49E-05
Cadmium	1.10E-05	NE	1.10E-05
Calcium	3.76E-04	NE	3.76E-04
Chromium III	2.07E-06	NE	2.07E-06
Chromium VI	4.53E-06	NE	4.53E-06
Copper	1.13E-04	NE	1.13E-04
Iron	2.46E-05	NE	2.46E-05
Manganese	1.65E-05	NE	1.65E-05
Mercury	4.58E-04	NE	4.58E-04
Molybdenum	2.16E-06	NE	2.16E-06
Nickel	4.30E-05	NE	4.30E-05
Silver	1.07E-04	NE	1.07E-04
Tin	3.62E-06	NE	3.62E-06
Titanium	1.80E-06	NE	1.80E-06
Vanadium	1.08E-04	NE	1.08E-04
Zinc	3.46E-05	NE	3.46E-05
CRITERIA POLLUTANTS/ ACID GASES			
Hydrogen Chloride	7.56E-04	NA	7.56E-04
Particulate Matter	8.77E-04	NA	8.77E-04
Carbon Monoxide	7.99E-04	NA	7.99E-04
Hydrogen Fluoride	6.15E-05	NA	6.15E-05
Nitric Acid	3.08E-05	NA	3.08E-05
Nitrogen Oxide	4.82E-03	NA	4.82E-03
Sulfur Dioxide	3.56E-03	NA	3.56E-03
Total (Hazard Index)	1.26E-02	1.66E-05	1.26E-02

Table 10-17

Infant Hazard Index for the Inhalation and Mother's Milk Ingestion Routes of Exposure for the Resident-B Scenario

Pollutant	Exposure Routes: Inhalation	Exposure Routes: Mother's Milk Ingestion	Total (Hazard Index)
ORGANICS			
Benzene	1.12E-08	4.22E-10	1.16E-08
Benzoic Acid	3.78E-10	4.61E-10	8.39E-10
Bis(2-ethylhexyl)phthalate	1.12E-07	1.32E-07	2.44E-07
Bromodichloromethane	6.32E-08	1.46E-09	6.46E-08
Butylbenzylphthalate	2.01E-09	2.95E-08	3.15E-08
Carbon Tetrachloride	1.05E-08	1.10E-08	2.15E-08
Chlorobenzene	6.47E-08	3.74E-10	6.50E-08
Chloroform	1.15E-07	1.33E-08	1.29E-07
Dibromochloromethane	1.17E-08	5.47E-10	1.23E-08
Di-n-butylphthalate	8.61E-09	8.64E-10	9.47E-09
Diethylphthalate	1.49E-07	1.24E-10	1.49E-07
Dimethylphthalate	5.66E-08	4.82E-12	5.66E-08
Dioxins/Furans (EPA TEFs)	1.21E-07	2.54E-06	2.66E-06
Heptachlor epoxide	6.28E-07	2.02E-06	2.64E-06
Methyl Chloride	3.95E-08	5.33E-09	4.48E-08
Methylene Chloride	7.54E-10	2.49E-10	1.00E-09
Styrene	1.44E-08	3.60E-10	1.47E-08
Toluene	1.34E-09	1.11E-11	1.35E-09
Xylene	3.70E-09	9.18E-14	3.70E-09
INORGANICS			
Aluminum	5.39E-06	NE	5.39E-06
Antimony	1.19E-06	NE	1.19E-06
Arsenic	1.07E-05	NE	1.07E-05
Barium	4.35E-05	NE	4.35E-05
Boron	4.93E-06	NE	4.93E-06
Cadmium	2.18E-06	NE	2.18E-06
Calcium	7.45E-05	NE	7.45E-05
Chromium III	4.10E-07	NE	4.10E-07
Chromium VI	8.99E-07	NE	8.99E-07
Copper	2.24E-05	NE	2.24E-05
Iron	4.87E-06	NE	4.87E-06
Manganese	3.28E-06	NE	3.28E-06
Mercury	9.09E-05	NE	9.09E-05
Molybdenum	4.28E-07	NE	4.28E-07
Nickel	8.53E-06	NE	8.53E-06
Silver	2.12E-05	NE	2.12E-05
Tin	7.17E-07	NE	7.17E-07
Titanium	3.57E-07	NE	3.57E-07
Vanadium	2.13E-05	NE	2.13E-05
Zinc	6.85E-06	NE	6.85E-06
CRITERIA POLLUTANTS/ ACID GASES			
Hydrogen Chloride	1.50E-04	NA	1.50E-04
Particulate Matter	1.74E-04	NA	1.74E-04
Carbon Monoxide	1.58E-04	NA	1.58E-04
Hydrogen Fluoride	1.22E-05	NA	1.22E-05
Nitric Acid	6.10E-06	NA	6.10E-06
Nitrogen Oxide	9.56E-04	NA	9.56E-04
Sulfur Dioxide	7.06E-04	NA	7.06E-04
Total (Hazard Index)	2.49E-03	4.75E-06	2.50E-03

Table 10-18

Infant Hazard Index for the Inhalation and Mother's Milk Ingestion Routes of Exposure for the Farmer Scenario

Pollutant	Exposure Routes: Inhalation	Exposure Routes: Mother's Milk Ingestion	Total (Hazard Index)
ORGANICS			
Benzene	1.96E-08	7.39E-10	2.03E-08
Benzoic Acid	6.62E-10	8.54E-10	1.52E-09
Bis(2-ethylhexyl)phthalate	1.97E-07	8.26E-07	1.02E-06
Bromodichloromethane	1.11E-07	2.56E-09	1.13E-07
Butylbenzylphthalate	3.53E-09	1.52E-07	1.56E-07
Carbon Tetrachloride	1.84E-08	1.92E-08	3.77E-08
Chlorobenzene	1.13E-07	6.56E-10	1.14E-07
Chloroform	2.02E-07	2.34E-08	2.25E-07
Dibromochloromethane	2.06E-08	1.37E-09	2.19E-08
Di-n-butylphthalate	1.51E-08	1.77E-09	1.69E-08
Diethylphthalate	2.62E-07	2.99E-10	2.62E-07
Dimethylphthalate	9.92E-08	1.41E-11	9.92E-08
Dioxins/Furans (EPA TEFs)	2.12E-07	5.56E-06	5.77E-06
Heptachlor epoxide	1.10E-06	8.38E-06	9.48E-06
Methyl Chloride	6.92E-08	9.34E-09	7.85E-08
Methylene Chloride	1.32E-09	4.37E-10	1.76E-09
Styrene	2.52E-08	6.32E-10	2.58E-08
Toluene	2.35E-09	1.94E-11	2.37E-09
Xylene	6.49E-09	1.61E-13	6.49E-09
INORGANICS			
Aluminum	9.44E-06	NE	9.44E-06
Antimony	2.08E-06	NE	2.08E-06
Arsenic	1.87E-05	NE	1.87E-05
Barium	7.62E-05	NE	7.62E-05
Boron	8.65E-06	NE	8.65E-06
Cadmium	3.83E-06	NE	3.83E-06
Calcium	1.31E-04	NE	1.31E-04
Chromium III	7.18E-07	NE	7.18E-07
Chromium VI	1.58E-06	NE	1.58E-06
Copper	3.93E-05	NE	3.93E-05
Iron	8.53E-06	NE	8.53E-06
Manganese	5.75E-06	NE	5.75E-06
Mercury	1.59E-04	NE	1.59E-04
Molybdenum	7.49E-07	NE	7.49E-07
Nickel	1.49E-05	NE	1.49E-05
Silver	3.72E-05	NE	3.72E-05
Tin	1.26E-06	NE	1.26E-06
Titanium	6.26E-07	NE	6.26E-07
Vanadium	3.74E-05	NE	3.74E-05
Zinc	1.20E-05	NE	1.20E-05
CRITERIA POLLUTANTS/ ACID GASES			
Hydrogen Chloride	2.63E-04	NA	2.63E-04
Particulate Matter	3.05E-04	NA	3.05E-04
Carbon Monoxide	2.78E-04	NA	2.78E-04
Hydrogen Fluoride	2.14E-05	NA	2.14E-05
Nitric Acid	1.07E-05	NA	1.07E-05
Nitrogen Oxide	1.68E-03	NA	1.68E-05
Sulfur Dioxide	1.24E-03	NA	1.24E-03
Total (Hazard Index)	4.36E-03	1.50E-05	4.37E-03

Table 10-19

Hazard Index Values For Adults, Children, and Infants in the Four Exposure Scenarios For Trial Burn Emissions Conditions

Exposure Scenario	Total Hazard Index		
	Adult	Child	Infant
Resident-A	8.51E-03	1.92E-02	1.26E-02
Resident-B	1.70E-03	3.85E-03	2.50E-03
Farmer	3.10E-03	7.08E-03	4.37E-03
Worker	8.71E-04	NA	NA

NA = Not applicable

TABLE 10-20

NON-CANCER RISK AT DETECTION LIMITS OF PREDICTED CHEMICALS BUT NOT DETECTED WHEN MEASURED (RESIDENT-A CHILD NON-CANCER HAZARD INDEX)

CHEMICAL	TRIAL BURN SAMPLE DETECTION LIMIT (UG/CM)	TRIAL BURN HAZARD INDEX AT DETECTION LIMIT
i-BERYLLIUM	1.00E+00	1.35E-03
i-COBALT	5.00E+00	2.68E-04
i-LITHIUM	5.00E+00	1.37E-04
i-SELENIUM	1.00E+00	1.34E-05
i-SILVER	1.00E+00	2.69E-04
i-THALLIUM	5.00E+00	1.34E-04
i-ZINC	5.00E+00	1.67E-06
p-ALDRIN	1.30E-01	6.13E-06
p-ATRAZINE	3.30E-01	1.86E-07
p-DDE	1.30E-01	7.45E-07
p-DDT	1.30E-01	4.02E-07
p-DIELDRIN	1.30E-01	9.03E-06
p-ENDRIN	1.30E-01	3.52E-06
p-ISODRIN	1.30E-01	8.11E-06
p-MALATHION	2.70E+00	7.37E-07
p-PARATHION	3.00E-01	1.61E-05
p-SUPONA	3.30E-01	6.25E-06
p-VAPONA	3.30E+00	1.22E-05
sv-1,4-DICHLOROBENZENE	1.67E+01	1.14E-06
sv-4,4-CHLOROBIPHENYL	1.67E+01	2.03E-06
sv-4-NITROPHENOL	1.67E+01	1.91E-05
sv-ACENAPHTHALENE	1.67E+01	7.96E-07
sv-ACENAPHTHENE	1.67E+01	7.88E-07
sv-BENZOIC ACID	1.67E+01	1.21E-08
sv-BENZO[A]PYRENE	1.67E+01	1.60E-06
sv-CARBAZOLE	1.67E+01	9.47E-06
sv-CHRYSENE	1.67E+01	1.59E-06
sv-DIBENZOFURAN	1.67E+01	0.00E+00
sv-DIBENZO[A,H]ANTRHACENE	1.67E+01	1.84E-06
sv-DIMETHYLDISULFIDE	1.67E+01	5.64E-06
sv-FLUORANTHENE	1.67E+01	1.19E-06
sv-FLUORENE	1.67E+01	1.19E-06

TABLE 10–20

NON–CANCER RISK AT DETECTION LIMITS OF PREDICTED CHEMICALS BUT NOT DETECTED WHEN MEASURED (RESIDENT–A CHILD NON–CANCER HAZARD INDEX)

CHEMICAL	TRIAL BURN SAMPLE DETECTION LIMIT (UG/CM)	TRIAL BURN HAZARD INDEX AT DETECTION LIMIT
sv–HEXACHLOROBENZENE	1.67E+01	5.95E–05
sv–HEXCHLOROCYCLOPENTADIENE	1.67E+01	2.29E–03
sv–PENTACHLOROBENZENE	1.67E+01	6.00E–05
sv–PHENANTHRENE	1.67E+01	1.58E–06
sv–PHENOL	1.67E+01	2.37E–06
sv–PYRENE	1.67E+01	1.58E–06
sv–QUINOLINE	NE	0.00E+00
v–1,1–DICHLOROETHENE	3.00E+00	4.03E–07
v–1,2–DICHLOROETHENE	3.00E+00	1.01E–08
v–1,2–DICHLOROPROPANE	3.00E+00	2.32E–08
v–BROMOMETHANE	3.00E+00	4.80E–07
v–ETHYLBENZENE	3.00E+00	1.85E–08
v–TETRACHLOROETHENE	3.00E+00	2.37E–08
v–TRICHLOROBENZENE	1.67E+01	1.53E–05
v–TRICHLOROETHENE	3.00E+00	3.00E–08
v–VINYL CHLORIDE	3.00E+00	6.17E–07
	TOTAL HI	4.71E–03

i = inorganic
v = volatile
sv = semivolatile
p = pesticide
g/sec = grams per second
ug/m3 = micrograms per cubic meter
NE = Not evaluated because: (1) no toxicity criterion available; or (2) no detection method available

Table 10-21

Non-Cancer Risks (a) of Predicted Release Products Which Were Not Sampled During the Trial Burn

Release Product	Non-Cancer Risk (a)
1,3- Dimethylbenzene	9.90E-12
4- Chlorobiphenyl	8.20E-07
4- Chlorophenyl methyl sulfone	1.80E-07
4- Chlorophenyl methyl sulfoxide	2.20E-08
Acetone	2.50E-11
Acetonitrile	3.20E-09
Ammonia	7.90E-05
Benzaldehyde	6.40E-08
Benzofuran	2.40E-06
Benzonitrile	3.70E-10
Biphenyl	2.20E-06
Cyanogen	1.30E-11
Dicyclopentadiene	2.20E-08
Diisopropylmethyl phosphonate	1.40E-08
Dimethylmethyl phosphonate	6.90E-06
Dithiane	1.20E-10
Methanol	6.40E-07
Pyridine	1.70E-11
Silicon (b)	2.50E-02
Sulfuric Acid Mist	8.20E-02
Urea (c)	8.80E-04
Yttrium	1.70E-07
Total	1.08E-01

(a) Risk values for all chemials were obtained from Table 10-9 for Resident A Child in Final Draft Human Health Risk Assessment (Weston, 1991).

(b) Silicon was measured in the trial burn, but the data were considered unusable (see Section 5). However, silicon was additionally evaluated using conservative assumptions and is further discussed in Subsection 10.3.2.2.

(c) There is no method for analysis available in the WESTON analytical laboratory.

Table 10-22

Summary of Non-Cancer Risks From CPMSOs, DIMP and DMMP at the Estimated Detection Limits

Population	Age	Hazard Index				
		CPMS	$CPMSO_2$	CPMSO	DIMP	DMMP
Resident A	Infant	3E-06	3E-06	3E-06	7E-07	1E-05
	Child	2E-06	2E-06	2E-06	6E-07	1E-05
	Adult	1E-06	1E-06	1E-06	3E-07	6E-06
Resident B	Infant	6E-07	7E-07	7E-07	2E-07	1E-05
	Child	5E-07	7E-07	7E-07	1E-07	2E-05
	Adult	2E-07	3E-07	3E-07	7E-08	8E-06
Farmer	Infant	1E-06	1E-06	1E-06	3E-07	2E-05
	Child	1E-06	1E-06	1E-06	3E-07	3E-05
	Adult	5E-07	6E-07	6E-07	1E-07	1E-05
Worker	Adult	1E-07	1E-07	1E-07	3E-08	1E-07

Table 10-23

Maximum Possible Risks From Silicon Based on Measured PM_{10} Levels

Population	Age	HQ Value[a]	
		RfD = 5.1E-05[b]	RfD = 1.0E-02[c]
Resident A	Adult	5.0E-01	2.5E-03
	Child	1.1E+00	5.6E-03
	Infant	7.4E-01	3.7E-03
Resident B	Adult	9.9E-01	5.0E-03
	Child	2.2E-01	1.1E-03
	Infant	1.5E-01	7.3E-04
Farmer	Adult	1.7E-01	8.7E-04
	Child	3.9E-01	2.0E-03
	Infant	2.6E-01	1.3E-03
Worker	Adult	5.1E-02	2.6E-04

[a] Based on the assumption that all PM_{10} material is silicon.
[b] Inhalation RfD value used in 1991 risk assessment.
[c] Inhalation RfD value currently recommended by EPA.

Table 10-24

Comparison of Predicted Soil and Air Levels of Lead Under Operating (Trial Burn) Emissions Conditions to Soil Cleanup and National Ambient Air Quality Standards (NAAQS)

Exposure Scenario	Maximum[a] Predicted Lead Soil Concentration (mg/kg)	Soil Cleanup[b] Level (mg/kg)	Predicted[c] Average Ambient Air Concentration (μg/m3)	NAAQS[d] ($\mu g/m^3$)
Resident A	4.8E-06	5.0E+02	3.9E-05	1.5E+00
Resident B	7.8E-06	5.0E+02	7.7E-06	1.5E+00
Farmer	4.6E-06	5.0E+02	1.3E-05	1.5E+00
Worker	6.9E-06	5.0E+02	1.2E-05	1.5E+00

[a]Assumed mixing depth of 0.1 m. Refer to Appendix 8A for these and other data.
[b]OSWER Directive 9355.4-02 (EPA, 1989b).
[c]Refer to Table 8-2 for these and other data.
[d]40 CFR 50. Three-month annual average.

SECTION 11
UNCERTAINTIES IN RISK ESTIMATES

11.1 INTRODUCTION

It is important to recognize that the risk estimates presented in this document are based on a number of assumptions, and that these assumptions introduce uncertainty into the risk estimates. Assumptions are required because of data gaps in our understanding of the toxicity of chemicals, and in our ability to estimate the true level of human exposure to chemicals released to the environment. In most cases, assumptions employed in the risk assessment process are intentionally conservative (that is, they are likely to lead to an overestimate of risk). It is important for risk managers and the public to take these uncertainties into account when interpreting the risk estimates derived for this facility.

Not all sources of uncertainty are of equal concern. For example, if a particular chemical or exposure pathway is found to contribute only a small fraction of the total risk to an exposed population, even large uncertainties in the exposure or risk estimates for that chemical or pathway may have little impact on the estimate of total risk. As previously discussed (see Subsection 10.3.1), the principal sources of cancer risk associated with releases from the SQI are inhalation of arsenic in ambient air and ingestion of BEHP that has been taken up into garden vegetables. For non effects, the largest HI values are contributed by inhalation of HCl, inhalation of particulate matter, and inhalation of metals (mainly barium, calcium, and mercury), but none of these chemicals (either alone or together) approaches a level of noncancer concern (Subsection 10.3.2).

Presented below is a general discussion of the principal sources of uncertainty in toxicity and exposure estimates, with special emphasis on those chemicals and pathways (above) which contribute the most to total risk.

11.2 UNCERTAINTIES IN EMISSION RATES

Emission rates during the trial burn were calculated based on analysis of three independent samples of stack effluent. Most chemicals which were detected were detected in all three samples, and there was usually good agreement among samples. Nevertheless, when these data were combined according to EPA procedure, the emission rate used to calculate exposure and risk was nearly always equal to the maximum measured value. Because the true mean emission rate is likely to be less than the maximum value, this approach is likely to result in an overestimate of exposure and risk. When a chemical was detected in at least one but not all of the samples, the emission rate was based on a conservative weighting of the detected and nondetected values. This approach is also likely to overestimate the true average emission rate. When a chemical was not detected in any of the three samples, the emission rate was assumed to be zero. This approach will lead to an underestimate of emissions for chemicals which are actually present but at levels too low to be detected. However, the absolute magnitude of the uncertainty in risk introduced by the occurrence of nondetects in some or all of the samples is small, because analytical detection limits for each chemical were selected so that the maximum risk which could be contributed by a nondetected chemical is low.

Some of the chemicals detected in stack samples were also detected in blank samples, indicating that the chemicals might be artifacts due to laboratory contamination. The EPA recognizes that certain chemicals (e.g., the phthalates) are such common laboratory contaminants that these chemicals are usually not evaluated unless site concentrations are at least 10 times higher than detected in the blanks. At the SQI, in order to be maximally conservative, the phthalates were evaluated, even though some could have been eliminated based on EPA's criterion. Thus, the risks contributed by the phthalates may very well be an artifact, especially the risks from BEHP, which were detected at higher levels in blanks than in stack samples.

A number of chemicals identified as possible stack release products in the 1991 risk assessment could not be detected during the trial burn. This could lead to an underestimation of risk if some of these chemicals were actually present, but at concentrations below the detection limits of the analytical methods. However, the detection limits used in the analysis were set sufficently low that even if all the chemicals not detected were actually present at their detection limits (this is considered to be extremely unlikely), neither the cancer risk nor the noncancer risk would exceed the benchmarks.

Some chemicals identified as possible stack release products in the 1991 risk assessment could not be analyzed for during the trial burn due to lack of approved sampling and/or analytical methods. This inability to measure the emission rates of some potential release products could lead to the underestimation of risk, but this is not believed to be of major concern. As presented earlier (see Tables 10-8 and 10-21), the predicted cancer risk from this group of chemicals is 2E-14 (more than 7 orders of magnitude below the benchmark), and the total Hazard Index based on predicted emission rates is 1E-01, 1 order of magnitude below the benchmark level of concern. Thus, there is very little uncertainty in the conclusion that the unmeasurable emission products from the SQI do not pose a significant risk to any of the maximally exposed populations.

11.3 UNCERTAINTIES IN EXPOSURE POINT CONCENTRATION VALUES

All of the human exposures evaluated in this risk assessment were based on environmental concentration values calculated from the emissions data using an EPA-based mathematical model to describe the atmospheric dispersion and deposition of the pollutants. Use of an atmospheric fate and transport model of this sort is an important source of uncertainty, but the error is very likely to be in the conservative direction. For example, EPA air quality models are generally designed to over-predict measured concentrations by a factor of 2-3. Several specific

assumptions employed in the modeling at this site that further increase the likelihood of overestimating exposure are summarized below.

- Building downwash causes higher air quality concentrations to occur than if no buildings or structures are present. The air quality modeling analysis included a conservative assessment of downwash potential for all structures associated with the SQI. Cylindrical structures were treated as rectangular structures to increase the potential for downwash. Also, adjacent structures were combined to form a single structure with greater downwash. The approach that was followed for the downwash analysis will cause an overestimation in the predicted air quality impacts.

- Pollutants that are emitted from the SQI stack are removed by both wet and dry deposition processes, thereby depleting the mass of pollutants in the air. However, the air quality modeling did not consider any removal processes in the calculation of ambient air concentrations. Consequently, the entire mass of the stack emissions is available to be inhaled as well as to be deposited as dry or wet deposition. This approach will result in over-prediction of both soil and ambient air concentrations.

- The scavenging coefficients that are used in the calculation of wet deposition are generally based on research from industrial power plants. The majority of the particles emitted from these facilities are sulfate aerosols. Sulfate aerosols have a higher affinity for water than the particulates emitted from the SQI. Therefore, scavenging coefficients based on these studies will cause higher wet deposition totals than would realistically be expected from the SQI.

- All material falling on the surface of vegetation by dry deposition was assumed to be retained, with none removed either by rainfall or by washing. This is very likely to result in an overestimate of the level of contaminants ingested via garden vegetables, and may also overestimate exposure via the beef pathway as well. This assumption would be mitigated to a degree by the assumption that none of the wet-deposited pollutant would remain.

Once a chemical enters soil as a result of wet or dry deposition, a number of processes may cause the concentration to decrease over time. For example, organic chemicals are subject to both biodegradation (breakdown by soil microbes) and

chemical degradation (photolysis, hydrolysis, oxidation, etc.), and all chemicals (including metal and other inorganics) are subject to leaching. For the purposes of maintaining maximal conservatism, this risk assessment made no adjustment for any of these fate processes. This almost certainly results in a significant overestimate of exposure to organic chemicals via soil pathways (including exposure to BEHP in garden vegetables), and will also overestimate exposure to inorganic chemicals.

11.4 UNCERTAINTIES IN HUMAN EXPOSURE PARAMETERS

There is wide variability between different people in the amount of contact they have with environmental media (e.g., water intake, breathing rate, vegetable consumption, soil ingestion, etc.). In accordance with EPA policy, the exposure parameters used in this risk assessment were selected to represent the high end of the exposure distribution curves. That is, the doses and risks calculated are intentionally derived to represent individuals with exposures well above average, and actual risks to most people will be lower. In addition to variability, there is also considerable uncertainty in some human exposure parameters. When dealing with these uncertainties, EPA typically seeks to be conservative. That is, when data are limiting, the default exposure parameters which EPA recommends are more likely to be high than low.

As noted above, the inhalation pathway accounts for nearly all noncarcinogenic risk and for much of the cancer risk, with the remainder of the cancer risk due to the vegetable ingestion pathway. The primary sources of uncertainty in estimating human exposure via these pathways are listed below.

- Most people spend a large majority of time indoors, but there is only limited information on the rate at which outdoor pollutants enter indoor air. Therefore, the indoor air concentration of all chemicals was assumed to be equal to the value predicted for outdoor air. This likely results in an overestimation of risk, especially for particulate matter and particle-bound metals and organics.

- There is wide variability in breathing rate in the population, depending mainly on the level and duration of physical activity. The breathing rates used in this risk assessment are based on national averages, and it is presumed that these are appropriate for the populations exposed at this facility. Nevertheless, this is a source of uncertainty.

- There is only limited information on the typical level of vegetables ingested from home-grown gardens, and these data come from studies at other locations. Thus, there is uncertainty whether these values are representative of actual site-specific intake rates. Considering that the Denver area has a shorter than average growing season and has relatively low rainfall (both of which tend to limit garden production), it seems likely that the values employed will result in an overestimate of home-grown vegetable intake.

- No site-specific data exist on the extent of chemical uptake into vegetables, so mathematical bioaccumulation models were employed to estimate vegetable tissue levels. These bioaccumulation models are based on limited observations of plant/soil concentration ratios (bioconcentration factors) which are known to depend on soil type and meteorological conditions. Thus, there is considerable uncertainty introduced by extrapolation of data from one location to another. In addition, these models do not account for the likelihood that organic chemicals may undergo metabolism and breakdown in the plant, or that some chemicals may escape from the plant by evapotranspiration. Thus, the plant concentration values estimated in this risk assessment are likely to be higher than actual.

11.5 UNCERTAINTIES IN CANCER SLOPE FACTORS

There is ongoing debate in the scientific community regarding the most appropriate way to quantify cancer risks to humans. For most chemicals, cancer potency data are only available from studies in animals exposed at very high doses, and there is uncertainty surrounding how to extrapolate from high dose to low dose, and how to extrapolate from animals to humans. The method currently employed by EPA assumes that, at low doses, cancer risk is linearly proportional to dose, and that there is no threshold (EPA, 1989). These assumptions may hold true for some carcinogens, but there is evidence that some chemicals may have non-linear dose-response curves,

and some may have non-zero thresholds. Thus, the basic EPA cancer risk model may overestimate cancer risk for at least some chemicals. In addition, when calculating the slope of the dose-response curve (the slope factor), EPA intentionally derives a value that is the 95% upper confidence limit of the slope. That is, there is a 95% probability that the true slope is lower. Thus, cancer risk estimates calculated using EPA slope factors have a high probability of being conservative.

Although a number of potentially carcinogenic chemicals were detected in the stack emissions, the total cancer risk is dominated by the contribution of arsenic (mainly by inhalation) and BEHP (mainly by ingestion in vegetables). Key uncertainties in the slope factors for these chemicals are summarized below.

- The inhalation slope factor for arsenic is derived from several studies in humans exposed in the workplace, so confidence in the slope factor is higher than for chemicals based on studies in animals. Nevertheless, the slope factor is still uncertain because of confounding factors in the study sample such as smoking and exposure to other chemicals, as well as uncertainties in actual exposure levels and durations. In addition, there is good evidence that the body can detoxify low levels of arsenic by methylation, and this raises the possibility that the dose-response curve may not be linear.

- The oral slope factor for DEHP is based on studies in rats and mice exposed to high levels of DEHP in the diet. Some minor uncertainty in the slope factor is introduced by lack of precise data on intake rates, but the main uncertainty relates to whether or not the liver tumors produced in the exposed animals are likely to occur in humans. Specifically, DEHP is believed to cause tumors by a mechanism involving the proliferation of subcellular organelles called peroxisomes. If so, the slope factor based on animals exposed at high doses is uncertain for two reasons: 1) peroxisome proliferation has a nonlinear dose-response curve, and so tumorigenicity may also be nonlinear, perhaps with a threshold; and 2) there may be significant differences between rodents and humans with respect to peroxisome induction, so there is uncertainty whether the data from rodents are applicable to humans.

11.6 UNCERTAINTY IN REFERENCE DOSES

Reference doses, like slope factors, are derived by EPA in a way that is intentionally conservative. That is, reference doses are set sufficiently low that there is high confidence that exposure at that level will not cause any adverse noncancer effects, even in the most susceptible humans. Thus, evaluation of noncancer risks using EPA reference doses is likely to overestimate the true level of noncancer risk.

As discussed in Section 9, EPA has not derived inhalation reference doses for a number of chemicals. These data gaps were filled by extrapolation of toxicity data from a variety of sources. The methods used sought to incorporate the same degree of conservatism as normally used by EPA, but use of non-validated reference doses is a source of uncertainty.

Only chronic inhalation reference doses were used to evaluate risks from the inhalation pathway, even though inhalation exposure will occur for an interval that is properly considered subchronic (2 years). This is not likely to cause a significant error for chemicals whose effects do not depend on exposure duration, but will result in an overestimation of risks for chemicals whose toxicity is cumulative. For example, the subchronic inhalation reference dose for barium is 10-fold higher than the chronic value, so use of the chronic reference dose may overestimate subchronic toxicity by up to 10-fold.

As noted above, the chemicals which contribute the largest HI values at the SQI include HCl, particulate matter, and a number of metals (primarily barium, calcium, and mercury), all via the inhalation exposure route. Although there is uncertainty in the inhalation reference doses for all of these chemicals, the HI values (both alone and in combination) are well below the level of noncancer concern, so there is very little uncertainty in the conclusion that noncancer effects are unlikely to occur in exposed populations.

11.7 SUMMARY

There are a number of assumptions which introduce uncertainty into the estimates of risk derived in this risk assessment. Most of these assumptions are likely to result in an overestimate of the true level of exposure and risk, so the risk values presented in this report should be considered to be conservative. More importantly, because these conservative estimates of both cancer and noncancer risk are approximately 2 orders of magnitude or more below the benchmark levels of health concern established for this facility, there is very little uncertainty in the conclusion that the levels of health risk to humans from operation of the SQI are less than the benchmark levels which have been defined as acceptable at this facility.

SECTION 11

CITED REFERENCES

EPA (U.S. Environmental Protection Agency). 1989. *Risk Assessment Guidance for Superfund, Human Health Evaluation Manual - Part A*. Interim Final, OSWER, Washington, D.C. EPA/540/1-89/002, December 1989.